PROCEEDINGS

of the

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Volume 56. **Issued November 4th, 1959**

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PROBLEMS IN THE COMPILATION OF A SPRAY CALENDAR FOR ORCHARDS IN BRITISH COLUMBIA[1]

D. P. PIELOU[2]

Introduction

Criticisms of the increasing complexity of pest control recommendations for certain types of crops, particularly fruit, are not infrequent. Such recommendations are usually made in the form of a so-called "spray calendar." The writer was successively secretary, vice-chairman and chairman of the committee responsible for the annual drafting of the spray calendar in British Columbia and, of necessity, took a central part in the many discussions as to the function, content, and format of the calendar. During this period the general structure of the calendar was considerably altered and this paper is an effort by the writer to give his views on the present situation.

It is illuminating to look at the British Columbia tree-fruit spray calendars for 1957, 1958 and 1959 (2, 3, 4) and compare them with the calendar for 1936 (6). It is best to go back no farther than twenty years or so, so that we remain in modern times with roughly the same serious insect pests and diseases as we have today, and roughly the same outlook and the same problems of orcharding in general.

In 1936 the tree-fruit spray calendar for British Columbia mentioned 18 pests and six diseases. It listed seven materials (lime-sulphur, oil, bordeaux mixture, nicotine, lead arsenate, strychnine and whitewash). Of the seven, three are deadly poisons. The calendar referred to the same six tree-fruits as it does today—apple, pear, peach, apricot, prune and cherry. In 1957 the same spray calendar (now called "Control of Tree-Fruit Pests and Diseases; With Information on Spray Thinning and Stop-Drop Sprays") covered 39 pests and 14 diseases (not counting virus diseases) and listed 33 pesticides. Although several of these pesticides are mild poisons, only two rank as deadly poisons (nicotine and strychnine; the latter for mice).

In 1936 the calendar was composed of approximately 2200 words, together with some 330 more on small fruits. In 1957 the number of words had increased to over 4000 and the information on small fruits had grown into a separate calendar.

The number of pests and diseases needing attention has approximately doubled in 21 years; but the number of materials has increased fourfold. Words have only doubled but the more leisurely phrasing of 1936 has given place to a brief, perhaps too brief, telegraphic style in 1957 in order to impart the information as concisely as possible. It is worthwhile noting, however, that in the 1957 calendar there are sections on spray-thinning, stop-drop sprays, mineral deficiencies, surfactants, and operation of concentrate sprayers, that were not included 21 years ago.

However, before we get too critical of our own affairs, let us look outside British Columbia. In Washington State the spray calendar (12) is now issued in the form of a 40-page booklet, using nearly four times as much paper as our own. It refers roughly to the same pests but mentions 48 chemicals against our 33. And Ontario issues three calendars to cover only five tree-fruits (9, 10, 11). Nova Scotia (8) and Quebec (7) each issue a single calendar for apples and pears; soft fruits are not grown on an appreciable commercial scale in these provinces (21).

The Background of Orchard Entomology in British Columbia

Recommendations for insect and pest control are influenced by various factors.

[1] Contribution No. 1, from the Regional Research Station, Canada Department of Agriculture, Summerland, British Columbia.

[2] Entomologist.

1. In the dry Okanagan Valley, where most of the tree-fruits of British Columbia are grown, insects, rather than diseases, dominate spraying practices.

2. Six fruits are involved and these are often planted in one small orchard, in several varieties. Interplanting is common in British Columbia and, in the interests of time and simplicity, orchardists favour pesticides that can be put usefully on all fruits.

3. Different fruits have different insect faunas. In British Columbia 46 species are listed (17) as of major economic importance on one or more of the six tree-fruits of the province. Of these, 28 occur on apple, 12 on pears, 10 on apricot, 11 on peach, 15 on prune and 12 on cherry. Some species, at a level sufficient to cause damage, occur on several fruits. But many of the most serious pests, and these dominate the spray programmes, occur on one or two tree fruits only, e.g., codling moth *Carpocapsa pomonella* (L.) on apple and pear; peach twig borer *Anarsia lineatella* Zell. on peach; black cherry aphid *Myzus cerasi* (F.) on cherry; pear psylla *Psylla pyricola* Foerst. on pear and mealy plum aphid *Hyalopterus arundinis* (F.) on apricot and prunes.

4. Susceptibility of various fruits, and varieties, to damage by different chemicals varies, often very greatly. For example, Trithion [*O, O*-diethyl *S*-(p-chlorophenylthiomethyl) phosphorodithoate] causes damage to the Golden Delicious and Red Delicious varieties of apple (36); so much so, that in spite of its otherwise excellent qualities as an orchard insecticide, we gave up intentions of recommending it in British Columbia. Fortunately there are suitable alternatives (37) with somewhat similar properties but lower phytotoxicity. A newly introduced pesticide, which proves phytotoxic in our orchard trials to any of our more important fruit varieties, is usually discarded if there are suitable alternative materials available.

5. A major factor in the selling of fruit today is that the fruits should have a very high finish. This is quite distinct from such obvious defects as worminess or gross misshape. The factor is purely an aesthetic one, something that would not arise in a hungry nation; it can be regarded as ridiculous but, nevertheless, it is most important in the sale of fruit. And the economic entomologist, being necessarily concerned with the economics of the industry that supports him, cannot afford to neglect it. The fact, from his professional point of view, is that the surface of fruits makes an excellent display surface for any sort of insect or disease damage, however trivial, and for any sort of blemish caused by spray material. Consequently, he must often concern himself with what are, strictly speaking, minor pests and he must be highly selective in recommending spray chemicals. Consider, for instance, the importance of finish in the sale of apples or peaches today as compared with potatoes, or turnips. Though the requirements for finish are much more exacting, ten acres of apples, or peaches, in British Columbia will, in some years, bring the farmer no more net income than ten acres of potatoes or turnips (21).

6. Recommendations made by the orchard entomologist must fit in with other orchard practices. The orchard entomologist is necessarily closely allied to the horticulturist and to the practices of actual fruit production. His position is quite unlike that of a medical entomologist working on, for example, malaria-carrying mosquitoes; such an entomologist is seriously concerned with only the one or two species of anophelines that are vectors which occur in his area; and there may be little reason for him to be in close contact with the medical man working on drugs for the cure of the disease. For instance: efficient concentrate spraying is only possible if adequate pruning has been done (40); fungicides used by plant pathologists can increase or decrease mite populations (33); the water and nitrogen balance of fruit trees almost certainly (36) affects aphid populations as it does in other plants (19); though lindane [1,2,3,4,5,6,-hexachlorocyclohexane] does not have the

tainting properties of the less pure benzene hexochloride (38) on fresh fruit, nevertheless, its taste can be detected in the processed apple sauce that is produced on a large scale in British Columbia as a means (21) of removing low grade apples from the fresh fruit market; compatibilities of insecticides have to be considered, not only with fungicides, but with blossom-thinning, "stop-drop" and minor-element sprays (35); at certain times spraying cannot be done with a concentrate machine because of the presence of tree-props in the orchard; and late-season application of pesticides is not always possible, not only because of the dangers of exceeding legal residue tolerances (20), but because unsightly, if innocuous, deposits of spray material may depress the grade of the fruit at the packing house (37).

How Comprehensive Should a Spray-Calendar Be?

The slowly increasing pest fauna, the rapidly increasing number of new chemicals, and the development of pesticide tolerance in insects and mites (18), inevitably brings up this question. Should a spray calendar include all available information on pest and disease control procedures? Or should it be restricted to a few of the most important pests and diseases, and most important control measures? A skeleton outline of essential control measures could almost be put on a postcard and some growers would like nothing better. But extension horticulturists want all the current information available; and many growers want some scope for choice in their spray programmes based on their experience of conditions in their own orchards.

The policy up to the present has been to make the British Columbia calendar fairly comprehensive; District Horticulturists have then abstracted, and issued in typewritten form, a brief minimum spray schedule for their own local areas. This, in fact, emphasizes why it would be unwise to restrict the general calendar in content; for what one District Horticulturist would consider the minimum schedule for his own area is not necessarily suitable for another area. For within a distance of 100 miles or so in the Okanagan Valley, there are quite large differences in insect fauna; in rainfall, soil and frost conditions; and in the fruits and varieties predominant (21, 24). For instance, south of Okanagan Falls the presence of San Jose scale, *Aspidiotus perniciosus* Comst., determines, to a large degree, the nature of dormant spray treatment; lime-sulphur plus oil is an essential recommendation there (23). In the Vernon area, on the other hand, San Jose scale is not present, and the addition of oil to the dormant spray may be a needless expense. The appearance of resistance to pesticides in insects and mites has been, in the first place, sporadic and restricted in location. This has been the situation in British Columbia with resistance to organic phosphates in the European red mite, *Panonychus ulmi,* (Koch), the apple rust mite, *Vasates schlechtendali* (Nal.) and possibly other mites (16, 31). The appearance of DDT-resistance in the codling moth, in 1957, was also localized, not merely as to geographical locality, but also in individual orchards in a given area (27). In the most recent British Columbia spray calendar (4), specific mention was given to recommendations for resistant strains.

There have been other reasons for increase in size of the calendar in recent years. The calendar originally referred to the application of chemicals as sprays for pests and disease control, together with information on the few pesticides not applied by this method. In the past six or seven years, however, the entomologists' and pathologists' techniques of spraying have been extended to the thinning of fruit by the application of materials that act by destroying most of the blossom (13). The chemicals used in British Columbia are dinitro-*o*-cresol compounds similar to those that are applied earlier in the season for insect and mite control, but they are used at a lower dosage. There is,

therefore, logical reason for the inclusion of such information on the spray calendar. Mineral salts (zinc, manganese, boron, magnesium) have been conveniently applied as spray solutions (41) and, as these compounds are used to correct physiological diseases, it is legitimate to include them on the spray calendar. Since some of these salts can also be applied by scattering on the ground, this information is also included on the spray calendar for the sake of completeness. However, we may pause to consider where such extensions of the content of the calendar may lead us. Application of such nitrogenous fertilizers as urea may be accomplished by spraying (12), though it is not recommended in British Columbia at present. If it is ever recommended it is reasonable to suggest that such information be put on the spray calendar. However, for completeness again, it might be argued that recommendations concerning conventional soil applications of similar fertilizers should also be included. In a process such as this, the original spray calendar for pests and diseases could grow into a complete outline of recommendations for general orchard practice.

It is fairly obvious that we have enough categories of diverse information on the calendar now, and, if there is any call for further additions, we should consider dealing with all spray applications, other than those for pests and diseases, in a separate publication.

How Many Calendars Are Necessary?

Ontario (9, 10, 11) issues three calendars and these cover five tree-fruits against our six. However, conditions are somewhat different in Ontario. Acreages are larger and some growers grow only one fruit, e.g., peaches. There is, therefore, good argument for the issue of calendars dealing with only one fruit or group of fruits. As already mentioned, Nova Scotia and Quebec, where soft fruits are not grown on an appreciable scale, each issue a single calendar covering apples and pears only.

However, in British Columbia, although many growers grow apples only, very few grow soft fruits only and very few indeed grow one kind of soft fruit only. Moreover, the peach, the most important soft fruit in British Columbia, has far fewer insect and disease enemies than in Ontario. For instance, two serious peach pests, the Oriental fruit moth, *Grapholitha molesta* (Busck) and the plum curculio, *Conotrachelus nenuphar* (Hbst.) are fortunately absent in British Columbia (17), and these two pests alone force Ontario fruit growers to undertake a spraying schedule (11) at least as extensive as that for apples (3) in British Columbia. Provided, therefore, we can reduce extraneous matter on the calendar, it is reasonable to continue with a single official general calendar. From this one calendar, local horticultural advisors will, no doubt, continue to abstract brief typewritten schedules to suit their districts and preferences. But if, as mentioned in the last section, more categories of information are to be covered in the future, then we will have to consider a second medium of publication; but it is suggested that the division should not be on the basis of separate calendars for separate fruits, for this would lead to much unnecessary duplication of information, as far as recommendations in British Columbia are concerned.

General Arrangement And Presentation

Twenty years ago the arrangement and presentation of a spray calendar was no great problem. Procedures could be grasped without much difficulty, whatever arrangement was used, because the number of pesticides available was small and did not change much from year to year. Now with much more information to impart, and with annual changes, the design of the spray calendar is a matter of concern if the grower is not to be disheartened by the mass of instructions offered him.

Arrangement may be made in three basic ways:

1. Listing by Pests and Diseases

This is, more or less, a catalogue of pests and diseases with alternative control measures, pesticide, rate of application and timing, listed for each. Up to 1957 the British Columbia tree-fruit calendar was of this kind (2). It was definitely not in the form of a programme or schedule for seasonal spraying. But local schedules were compiled from it by district advisory horticulturists. It is extremely economical of space, and involves a minimum duplication of information since a pest or disease is referred to only once, on whatever crop it occurs. Control measures are also listed only once in a separate section and referred to by index numbers opposite each pest or disease.

This form of presentation is the obvious one for entomologists or pathologists whose interests are centred around the insects or diseases. Moreover, the almost complete change, in British Columbia to concentrate spraying has made it possible for the orchardist to apply sprays only when it is obviously necessary, so that a pre-arranged programme, except in the case of codling moth, is no longer necessary. In the past, when the spraying of an average ten-acre orchard might take several days, instead of five or six hours as now, such short-notice spraying was often out of the question.

2. Listing by Crops

This is the basic arrangement for the pest and disease-control calendar for vegetable and field crops in British Columbia (5). Here it appears to be a natural method as the number of crops, or categories of crops, is nineteen, and it is difficult to see what other arrangement could have been used. There is also, in this calendar, a section on pests or diseases of a general nature (grasshoppers, etc.).

3. Listing by Date

This is a true calendar with the dates of application being indicated: dormant, pre-pink, post-blossom, etc. It is followed conveniently in some calendars devoted solely to one crop, e.g., apple in Ontario (9). If several crops are involved it is followed with difficulty unless some subdivision, on a crop basis, is also made. This is the form that horticultural advisors seem to prefer as most natural for the grower. However, since it soon becomes obvious that the seasonal calendar must be subdivided on a crop basis, some duplication will occur because of insects and diseases that are common to several crops. This means a larger calendar. In fact, the 1958 calendar for British Columbia tree-fruits was revised (3) on this basis and its area is one and one-half times that of the 1957 calendar. Even so, it was found necessary to include a section on "miscellaneous pests" for those pests that did not fit easily into a seasonal spray schedule (earwigs, cutworms, mice, etc.). Such duplication, limited to the extent that all information can be presented on one chart, is perhaps, not entirely undesirable because it can serve to reiterate important parts of the recommendations to growers.

Introduction of New, and Removal of Old Spray Chemicals

This question has become a major one because of the flood of new materials available. It is a problem that hardly existed before the era of DDT. The following questions arise:

1. How extensive should experimental work be before a new material is recommended to the grower? The entomologist or pathologist normally wants several years of experiment before he is certain of his judgment; for seasonal differences from year to year often profoundly affect insecticidal efficiency, or degree of phytotoxicity. An older generation of orchard entomologists (14), held that a period of not less than five years was necessary to test a pesticide in the field; entomologists of today's tempo have generally shortened this period, but the shortening cannot go too far. An example of this is our recent experience with Trithion (36). This material was so satisfactory, after trials in 1955 and

1956, that we considered recommending it for the 1957 calendar but finally decided against doing so. This was fortunate for the material caused such extensive damage to leaves, and reduced the crop in the 1958 trials, that we have been forced to discard it.

2. If chemicals already recommended are satisfactory, is there any point in emphasizing new materials until they are needed, or unless they have some outstanding new advantage? It is generally felt that the answer to this question is no; however, in practice, very few chemicals already recommended are satisfactory in every respect and usually a case can be made for the inclusion of a well-tested new material.

3. Should cost be a factor in putting a new material on the calendar? New materials are generally relatively expensive; however, the price is usually reduced shortly after the preparation comes into widespread use. The usual practice has been to introduce new materials slowly. Thus, although the effectiveness of diazinon as an orchard insecticide was already apparent to us (37), it was first inserted, in view of its initial high price, on the 1957 spray calendar (2) only for the control of black cherry aphid. This was because there were then objections to almost all other materials used against this pest (37) and the high priced diazinon seemed to have a place in protecting a high-value fruit. A year later (3), with the price substantially reduced, it was recommended for all aphids on tree-fruits and for eye-spotted bud moth, *Spilonota ocellana* (D. & S.). In the most recent calendar (4), diazinon has been recommended against a wide range of pests.

4. Should we introduce a new material, excellent in every respect, but effective against only a few pest insects? Such a policy may lead to an expensive spray schedule in that several materials may be needed in a given application. And, in addition, this policy may lead to the listing of even more materials on the calendar.

5. Should materials be introduced that appear to be incompatible with natural and established biological control? The biological balance between predator (or parasite), and prey, holds insect populations at a fluctuating, but more or less, constant level; however, the level is much influenced by climatic conditions, or by conditions that are themselves influenced by climate (1). It is unfortunate for fruit growers in British Columbia that, under the warm, arid conditions of the interior, the level at which, for instance, codling moth populations persist, is high. Two summer generations and a partial, at least, third generation are usual. With this high biotic potential, control with introduced species of parasites has not been commercially successful in spite of the establishment of the parasites (22). Growers in Nova Scotia are fortunate in that they can rely to a greater extent on natural control and to a lesser extent on chemical control (34); the reverse is the situation in British Columbia (23, 28, 32). Moreover, control with chemicals of moderate toxicity (30) has not been as successful in British Columbia as it has been in Nova Scotia where conditions are such that the codling moth rarely passes through a second generation. The Nova Scotia spray calendar is, in fact, the smallest in Canada for tree-fruits and refers to the fewest chemicals (8). In British Columbia a fully effective material must be used for codling moth whatever the side effects may be. DDT, with its consequent upsurges of mite populations, had to be accepted to save the grower from disaster (22) and Sevin [N - methyl - 1 - napthyl carbamate], which has the same disadvantage, will also have to be accepted now that DDT resistance has appeared in the codling moth in British Columbia (27). On other fruits, however, where DDT has not been so indispensable, we have tried to restrict use of this insecticide; and for the same reason Sevin is, at present, recommended only for apple pests (4).

6. Should highly toxic pesticides be recommended? The use of very poisonous materials such as TEPP [Bisdiethylphosphoric anhydride] is com-

mon on many parts of the world. However, local conditions must determine if official recommendations for such pesticides are to be made. The Okanagan Valley of British Columbia is noteworthy in that practically all the fruit is grown in small, highly-productive, family-operated orchards; although approximately one-half of the total of Canada's annual crop of tree-fruits comes from the Okanagan Valley, this aspect of its production is not generally known. The average orchard is under eight acres and approximately one-fifth of the holdings are less than two and one-half acres (21). There are houses on almost all these orchards. In addition, with the increasing residential population of the Okanagan Valley, many small lots, of a quarter of an acre or so, have been cut out of orchards and sold as homesites. The human population in the rural area is therefore much higher than in many other places where orchards are much larger. The population contains a high percentage of children who inevitably wander into the orchards. The dangers to them, particularly from cover crops contaminated with the more poisonous organic phosphates, can readily be appreciated. Although our attitude in the matter may seem to be unusually rigid, we have therefore adopted, in view of the peculiar British Columbia conditions, a firm policy of not recommending (and therefore doing only limited experimentation on) pesticides highly toxic to man. Our view has been that an adequate selection of reasonably safe materials has been available for the problems of the moment. For this reason we have done little with systemic insecticides until very recently, when suitable systemics of sufficiently low mammalian toxicity, such as Dimethoate [*O, O*-Dimethyl *S*-(*N*-methylcarbamoylmethyl phosphorodithioate] were developed.

7. How should pesticides be recommended to comply with legal tolerance requirements? A new material is not introduced on the spray calendar in British Columbia until a tolerance has been established under the Food and Drugs Act in Canada, and a permanent tolerance established under the Pesticides Chemicals Amendment to the Federal Food, Drug and Cosmetics Act in the U.S.A. The latter requirement is accepted because a considerable portion of fruit from British Columbia is shipped and sold in the U.S.A. and it would not be economical, in packing houses, to keep fruit sorted on the basis of the pesticides it had received during the season. Information that the grower wants, in this respect, is how close to harvest can pesticides be applied without danger of exceeding legal tolerances. Data on this point were included on the most recent calendar issued (4). In estimating these periods, however, other factors besides the purely chemical aspect of residues were considered. According to Mr. K. Williams, Chemistry Laboratory, Summerland, B.C., some materials, such as Sevin, have such a high tolerance that they can be applied the day before harvest, at the recommended rates of application, without fear of exceeding the legal tolerance. However, the wettable-powder formulation leaves an unsightly, though harmless, deposit and removal of such an appreciable deposit would probably add considerably to packing-house costs. Though emulsions do not have this drawback, wettable-powder formulations are preferred in British Columbia (35).

The removal of older materials from the calendar also presents problems. Some chemicals were removed without difficulties. Thus, methoxychlor [1,1,1 - trichloro - 2,2 - bis(*p*-methoxyphenyl ethane], as an alternative to DDT for codling moth, was never very popular with growers and it was removed simply because, since it was more expensive than DDT, very little was being sold. Others, such as cryolite (sodium alumino-fluoride), also once used against codling moth, was rapidly abandoned when something better was available. Since they were no longer used, their removal was no problem. On the other hand, we abruptly removed lindane without reference to the growers, once it became evident that it was being mis-

used and causing tainting of processed fruit. Some materials have been removed very slowly. Thus, the use of dormant oil has gradually declined; mixtures of dinitro compounds and oil are no longer recommended. However, lime-sulphur plus dormant oil still persists because it has been the only consistently effective material against San Jose scale in the southern Okanagan Valley. Nevertheless, the newer organic phosphates and carbamates offer promise against this pest, and it is possible that dormant oil will disappear completely from the calendar before long; unless pesticide-resistance problems increase to the point that we are forced to rely more on dormant oil sprays. Oil is an effective dormant material but is prone to cause plant damage if not used properly; there do not, however, appear to be examples of any insects (18) that have developed resistance to oils.

A few growers use materials (mainly on strength of advertisements in U.S. fruit grower magazines) that have never been recommended in British Columbia. If such materials are registered for use on ary plant anywhere in Canada, then there is no legal barrier to their purchase by a fruit grower. Since we have always had good reason for not recommending such materials, nothing is gained by indicating rates of application, etc. for them on the calendar.

How Many Materials for One Pest?

The reason that several materials are listed for control of one pest or disease may simply be that new materials are recommended, while at the same time, older materials are still widely used and only slowly being supplanted. However, there are often other good reasons why several alternatives should be listed. For instance, up to 1957, six materials (2) were listed for the control of the rust mite, *Vasates schlechtendali* (Nal.). That, on occasion, has been a cause of complaint. The argument has been: why not list just the best one or two measures? In the dormant season the recommended materials included dinitrocresol, lime-sulphur alone, and lime-sulphur plus oil. These alternatives were given because of other pests that might be present at the same time. Dinitro-*o*-cresol controls rust mite effectively and is a more pleasant material to handle than lime-sulphur. On the other hand, if the blister mite, *Eriophyes pyri* (Pgst.) is also prevalent, lime-sulphur is the preferred material because it is more effective than the dinitros against this species. And lime-sulphur plus oil is the best spray material if San Jose scale is present; lime-sulphur alone is less effective and the dinitros are of no use against this species (23). Three different types of summer sprays were also listed for the rust mite because evidence of abundance of the mite may not be apparent until the season is well advanced. The recommended materials were Aramite [2-(*p-tert.*-Butylphenoxy) - isopropyl 2' - chloroethyl sulphite] which is very effective but causes damage on pears (3, 15); Sulphenone [4-chlorodiphenyl sulphone] which is less effective (15) but can be used on pears; and wettable sulphur which is cheap and effective but is more likely to cause foliar and fruit injury than the other two substances (29).

Problems of Concentrate Spraying

The orchard spray calendar of British Columbia is unique in that it is designed around application of sprays by mobile, air-blast concentrate sprayers. High-volume sprays, whether applied by gun-machines or by automatic equipment, are now little used by orchardists in this province (26). Specification of rate of application was simple with such dilute sprays. Spray mixtures were made up at a given concentration and the material applied until the leaves were dripping; because of this run-off, excess deposition was impossible unless the leaves were allowed to dry and then resprayed. Application by air-blast concentrate sprayers, however, is equally simple provided the machine is correctly designed and ad-

justed and the rules for concentrate spraying are followed. Marshall (26) has defined efficient concentrate spraying as that in which output, rate of travel, and nozzle adjustment, of the moving air-blast machine is such that the whole tree is uniformly sprayed with no drip from any of the leaves or fruits. There is, therefore, a brief note on concentrate application on the spray calendar. There is also considerable mention, with somewhat different detail, on the compatibility chart (35). Perhaps all the information should be in one place.

Rate of application is specified on the total amount of material to be applied per acre. According to Mr. K. Williams, Chemistry Laboratory, Summerland, B.C., extensive data accumulated over several years show that this amounts, in a mature British Columbia orchard, to specifying the amount of DDT deposited on a square inch of leaf or fruit surface, and in practice if the correct procedure is adopted, the deposits do not vary more than would be expected from a suitable mean value. The instruction on the calendar is: "Determine tank output on acreage basis; e.g., if tankful covers 1¾ acres, use 1¾ times the material listed in column of the chart titled 'amount per acre' when filling the tank." The merits of specifying rates of application in this way have been dealt with by Marshall (26). Attempts to specify the strength of materials in the tank of the concentrate sprayer, without reference to the output-per-acre of the machine, lead to most complex instructions (12).

On the other hand, we do retain a column in the "Formulae" section of the spray calendar that indicates dilutions for application by hand-gun methods. This is because a few growers still own the older machines, and also because the use of dilute spray mixtures applied by hand-guns to the pump of the concentrate machine, is the most economical method for very young trees. Young bearing trees are best sprayed with the usual air-blast concentrate at the standard per acre rate, but with the spray shut off between gaps in the trees. This leads to a lower per-acre output than is indicated on the spray calendar but this is such an obvious procedure that it is not mentioned.

References

1. Andrewartha, H. B., and L. C. Birch. The distribution and abundance of animals. University of Chicago Press. Chicago. 1954.
2. Anonymous. Control of tree-fruit pests and diseases. British Columbia Dept. Agr. poster. 1957.
3. Anonymous. Control of tree-fruit pests and diseases. British Columbia Dept. Agr. poster. 1958.
4. Anonymous. Control of tree-fruit pests and diseases. British Columbia Dept. Agr. poster. 1959.
5. Anonymous. Control of vegetable and field-crop pests and diseases. British Columbia Dept. Agr. poster. 1957.
6. Anonymous. Fruit spray calendar. British Columbia Dept. Agr. poster. 1936.
7. Anonymous. Guide de protection des pommiers. Quebec Dept. Agr. poster. 1956.
8. Anonymous. Nova Scotia spray calendar for apples and pears. Nova Scotia Dept. Agr. and Marketing poster. 1957.
9. Anonymous. Spray calendar for apples. Ontario Dept. Agr. poster. 1958.
10. Anonymous. Spray calendar for cherries, grapes, pears and plums. Ontario Dept. Agr. poster. 1958.
11. Anonymous. Spray calendar for peaches. Ontario Dept. Agr. poster. 1958.
12. Anonymous. Spray recommendations for tree-fruits in eastern Washington. State Coll. Washington Ext. Bull. 419 (rev.). 40 pp. 1958.
13. Batjer, L. P., and A. H. Thompson. Are blossom thinning sprays commercially feasible? Washington State Hort. Assoc., Proc. 42nd Ann. Meeting 187-194. 1946.
14. Caesar, L. The history of orchard spraying in Ontario. Ontario Dept. Agr. Bull. 462. 32 pp. 1948.
15. Downing, R. S. Acaricide trials in British Columbia orchards, 1950. Proc. Ent. Soc. British Columbia 47: 1-4. 1951.

16. Downing, R. S. Strains of the European red mite **Metatetranychus ulmi** (Koch) resistant to parathion and malathion in British Columbia. Proc. Ent. Soc. British Columbia 51: 10-11. 1954.
17. Downing, R. S., C. V. G. Morgan, and M. D. Proverbs. List of insects and mites attacking tree-fruits in the interior of British Columbia. Proc. Ent. Soc. British Columbia 52: 34-35. 1956.
18. Hoskins, W. M., and H. T. Gordon. Arthropod resistance to chemicals. In Annual Review of Entomology 1: 89-122. Annual Reviews, Inc., Stanford, California. 1956.
19. Kennedy, J. S. Physiological condition of the host-plant and susceptibility to aphid attack. Ent. exp. & appl. 1: 50-65. 1958.
20. Legault, R. R., and N. Eranzkeit. Can we meet residue tolerances? Washington State Hort. Assoc., Proc. 53rd Ann. Meeting 27-32. 1957.
21. MacPhee, E. D. The report of the Royal Commission on the tree-fruit industry of British Columbia. Queen's Printer, Victoria, B.C. 1958.
22. Marshall, J. Applied entomology in the orchards of British Columbia, 1900-1951. Proc. Ent. Soc. British Columbia 48: 25-31. 1951.
23. Marshall, J. A decade of pest control in British Columbia orchards. Proc. Ent. Soc. British Columbia 49: 7-10. 1952.
24. Marshall, J. Fruit insects and mites of the interior. Proc. Seventh Pacific Sci. Congr. 4: 125-128. 1949 (1953).
25. Marshall, J. Trend and practice in control of orchard insects. Ann, Rep. Oregon Sta. Hort. Soc. 45: 15-17. 1953.
26. Marshall, J. Concentrate spraying in deciduous orchards. Pub. 1020. Canada Dept. Agr., Ottawa. 1958.
27. Marshall, J. DDT-tolerant strain of the codling moth. British Columbia Fruit Growers' Association Quart. Rep. 3 (2): 13-14. 1958.
28. Marshall, J., and C. V. G. Morgan. Notes on the limitations of natural control of phytophagous insects and mites in a British Columbia orchard. Canadian Ent. 87: 1-5. 1955.
29. Martin, H. The scientific principles of plant protection. 3rd ed. Edward Arnold & Co., London. 1940.
30. Morgan, C. V. G., and N. H. Anderson. Some aspects of a ryania-glyodin spray schedule in British Columbia apple orchards I. Can. J. Pl. Sci. 37: 423-433. 1957.
31. Morgan, C. V. G., and N. H. Anderson. Notes on parathion-resistant strains of two phytophagous mites and a predacious mite in British Columbia. Canadian Ent. 90: 92-97. 1958.
32. Morgan, C. V. G., and N. H. Anderson. Can orchard pests be controlled biologically in British Columbia? Research for Farmers 4 (1): 6-7. 1959.
33. Morgan, C. V. G., N. H. Anderson, and J. E. Swales. Influence of some fungicides on orchard mites in British Columbia. Can. J. Pl. Sci. 38: 94-105. 1958.
34. Pickett, A. D., W. L. Putnam, and E. J. LeRoux. Progress in harmonizing biological and chemical control of orchard pests in Eastern Canada. Proc. 10th Int. Congr. Ent. 3: 169-174. 1956 (1958).
35. Pielou, D. P. Some problems in the compilation of a compatibility chart of orchard spray chemicals for use in British Columbia. Proc. Ent. Soc. British Columbia 56: 1959.
36. Pielou, D. P., and R. S. Downing. Trithion as an orchard insecticide. Proc. Ent. Soc. British Columbia 55: 17-23. 1958.
37. Pielou, D. P., and M. D. Proverbs. Diazinon—a summary of recent work on a new orchard insecticide. Proc. Ent. Soc. British Columbia 55: 3-6. 1958.
38. Proverbs, M. D., compiler. Effect of benzene hexachloride on the odour and flavour of fruit. Canada, Dept. Agr., Sci. Serv. Res. Notes Ser., Ent., No. E-1. 1948.
39. Proverbs, M. D. Chemical control of aphids in British Columbia orchards. Proc. Ent. Soc. British Columbia 51: 23-30. 1954.
40. Waddell, D. B., and J. M. McArthur. Effects of pruning on spray deposits from concentrate orchard sprayers. Can. J. Agr. Sci. 34: 444-450. 1954.
41. Woodbridge, G. G. Why mineral supplements are used in fruit sprays. Country Life in British Columbia 31: March, p. 10. 1955.

A Note on the Gordon Stace-Smith Beetle Collection

In volume 55 (1958) of our Proceedings, I stated that Mr. Stace-Smith had 2400 species of British Columbia beetles in his collection. He DID have, but that was a count he sent me some time ago. As soon as he received his copy of our Proceedings he hastened to tell me that he had well over 2700 species, with at least 50 more on hand which would bring the total number to 2800 species, plus or minus a few, all from this Province.

—*G. J. Spencer, University of British Columbia, Vancouver.*

CONTROL OF THE ROCKY MOUNTAIN WOOD TICK, DERMACENTOR ANDERSONI STILES (Acarina: Ixodidae), WITH GROUND SPRAYS OF DIELDRIN AND HEPTACHLOR[1]

L. COLIN CURTIS

The Rocky Mountain wood tick, *Dermacentor andersoni* Stiles, is a pest of considerable medical and veterinary importance in Western Canada. Not only may its bite produce tick paralysis, but it is the vector of the causal organisms of at least Rocky Mountain spotted fever, Colorado tick fever, and tularaemia in this region (Gregson, 1956; Banfield, 1956).

Satisfactory control of this pest insofar as it affects livestock is obtainable by spraying the animals themselves with B.H.C. rather than the terrain over which they range (Gregson, 1951b). There remains the problem of protecting human beings who enter the habitat of the tick for recreational purposes, for example in limited areas around campsites and summer cottages. This is a report on the reduction in numbers of the tick by spraying the soil and vegetation with suitable acaricides.

A number of trials of this type have been made in Texas for control of the Lone Star tick, *Amblyomma americanum* (L.), by Smith and Gouck (1945), with DDT; by Gouck and Smith (1947), with DDT, nicotine sulphate, and pyrethrum; by McDuffie *et al.* (1950), with DDT, BHC, chlordane, parathion, and toxaphene; and by Therrien *et al* (1953, 1954), with dieldrin, aldrin, lindane, DDT, chlordane, Sulphenone, Neotran, n-butylacetanilide, and heptachlor, of which dieldrin proved most effective in both mortality and persistence. Gouck and Fluno (1950) carried out plot tests and large-scale aerial sprays in Massachusetts against the American dog tick, *Dermacentor variabilis* (Say), in which both DDT and dieldrin proved effective.

In 1956 and 1957 plot trials were carried out at Kamloops against the Rocky Mountain wood tick, with dieldrin in 1956 and dieldrin and heptachlor in 1957. The site selected was a fairly level, tick-free area of rangeland in the enclosure of the Royal Canadian Naval Ammunition Depot, which was free from interference by man or livestock. The vegetation was typical of overgrazed rangeland, being a mixture of range grasses with Russian thistle, *Salsola kali* var. *tenuifolia* Meyer, and rabbit brush, *Bigelovia graveolens* Nutt.

Methods and Materials

In 1956, 12 plots of 0.025 acre each were used, arranged in a randomized block. At the start eight of the plots were stocked with ten pairs of wild-caught ticks each, and 24 hours were allowed for the ticks to assume a normal questing position on the vegetation. Four of these plots were sprayed with dieldrin at 0.25 lb. per acre, and the remainder retained as checks. Counts were made after 24 and 48 hours, and weekly thereafter. Since the ticks on the sprayed plots showed a high rate of survival after the second count, a further four plots were stocked a week later. Three of these were sprayed with dieldrin at 0.5 lb. per acre, 20 per cent emulsifiable concentrate being applied in both cases in water with a knapsack sprayer at 40 gal. per acre.

Counts were made by sweeping with a standard tick drag, consisting of a square yard of white flannelette, until the area had been traversed three times without further recoveries. Captured ticks were returned to the plots after being counted.

[1] Contribution No. 2, Entomology Laboratory, Research Branch, Canada Department of Agriculture, Kamloops, British Columbia.

[1] Dieldrin-20, emulsifiable concentrate containing 1 lbs. per gal. technical dieldrin (hexachloroepoxyoctahydro-endo, exo-dimethanonaphthalene), Shell Oil Co. of Canada, Chemical Divn., Toronto, Ont.

[2] Heptachlor 2E, emulsifiable concentrate containing 2 lbs. per gal. technical heptachlor. (1, 4, 5, 6, 7, 8, 8-heptachloro-3a, 4, 7, 7a-tetrahydro-4, 7-methanoindene). Velsicol Chemical Corp., Chicago, Ill.

In the spring of 1957, dieldrin and heptachlor were each applied at 0.5 and 1.0 lb. per acre. Fifteen plots were laid out in a randomized block design, each having an area of 0.01 acre. The materials were diluted to give the required amounts at a spraying rate of 30 gal./acre, and were applied with a power sprayer using a hand gun. Counts were made after 24 and 48 hours, and approximately weekly thereafter until the end of the experiment. The reduction in numbers was calculated by Abbott's formula (Abbott, 1925).

TABLE I

Numbers of live ticks taken by dragging at various intervals in triplicate plots sprayed with dieldrin[1] or heptachlor[2] at two rates per acre on April 8th, 1957. Each plot having been stocked with ten pairs one day before spraying.

	Untreated	dieldrin		heptachlor	
		0.5 lb.	1.0 lb.	0.5 lb.	1.0 lb.
April 9 — 24	25	25	18	12
April 10 — 27	14	14	16	18
April 19 — 28	7	2	9	3
April 24 — 35	3	1	5	1
Percentage Reduction —	—	91	98	86	98

Results and Discussion

In 1956, no ticks were recovered after two weeks in the plots treated with dieldrin at 0.5 lb. per acre, although the initial rate of mortality was low. In 1957, dieldrin and heptachlor at 1 lb. per acre each nearly eliminated the ticks within three weeks.

The low initial rate of mortality may be partly accounted for by the activity pattern of the ticks, since Gregson 1951a) has shown that not all of a given batch of ticks are exposed on the vegetation at any one time. Those exposed at the time of spraying would be reached by droplets of insecticide immediately, whereas the remainder would be affected only by the deposit on the vegetation when they emerged from shelter. For the purpose of the experiment, this treatment is probably adequate, since the period of outdoor recreational activity overlaps only the last week or so of tick activity even in the mountain areas, where the tick season is latest.

Summary

Dieldrin and heptachlor, sprayed on artificially infested rangeland plots at 1.0 lb. per acre, each reduced numbers of the Rocky Mountain wood tick, *Dermacentor andersoni* Stiles, within three weeks. Lower dosages were less effective.

Acknowledgment

Grateful acknowledgment is made to the Officer in Charge, Royal Canadian Naval Ammunition Depot, Kamloops, B.C., who made available a very suitable site for the tests.

References

Abbott, W. S. 1925. A method of computing the effectiveness of insecticides. J. Econ. Ent. 18: 265-267.

Banfield, A. W. F. 1956. An investigation of ticks as disease vectors in Banff National Park, Alberta. Can. J. Zool. 34: 417-423.

Gouck, H. K. and J. A. Fluno. 1950. Field tests on control of the American dog tick in Massachusetts. J. Econ. Ent. 43: 698-701.

Gouck, H. K. and C. N. Smith. 1947. DDT to control wood ticks. J. Econ. Ent. 40: 303-308.

Gregson, J. D. 1951a. Notes on the spring activity of the Rocky Mountain wood tick, **Dermacentor andersoni** Stiles. Proc. Ent. Soc. British Columbia. 47: 4-7.

Gregson, J. D. 1951b. Winter and spring ticks and their control. Can. Dept. Agr. Div. Ent. Processed Pub. No. 123.

Gregson, J. D. 1956. The Ixodoidea of Canada. Can. Dept. Agr. Pub. 930.

Hunter, G. W. III, F. M. Phillips, A. P. Moon, M. G. Radke, J. S. Williams, D. H. Shamer and G. M. Padilla. 1954. Studies on the lone star tick. III. Results of additional plot tests of potential acaricides [Abstract]. J. Parasit. 40 (No. 5, Sec. 2): 30.

McDuffie, W. C., W. G. Eddy, J. C. Clark, and C. N. Husman. 1950. Field studies with insecticides to control the lone star tick in Texas. J. Econ. Ent. 43: 520-527.

Smith, C. N., and H. K. Gouck. 1945. DDT to control ticks on vegetation. J. Econ. Ent. 38: 553-555.

Therrien, A. A., G. W. Hunter, III, A. P. Moon, A. L. Adams, D. E. Potts, M. G. Radke, J. S. Williams, and J. E. Webb, Jr., 1953. Studies on the lone star tick. II. Preliminary plot tests of potential acaricides [Abstract]. J. Parasit. 39 (No. 4, Sec. 2): 26.

Therrien, A. A., G. W. Hunter, III, A. P. Moon, and A. L. Adams. 1954. Tests of potential acaricides against the lone star tick. J. Econ. Ent. 47: 76-78.

ANNOTATED LIST OF FOREST INSECTS OF BRITISH COLUMBIA PART IX—CARIPETA SPP. (Geometridae)[1]

D. A. Ross[2] and D. Evans[3]

Caripeta larvae feed on the needles of conifers but no appreciable defoliation by any of the three local species has been recorded in British Columbia. Full grown larvae are about 1½ inches long and may have one or two indistinct dark transverse lines on the front of the head. Body colours are for the most part dull, variable with sometimes obscure brownish X to H markings on the dorsum, darkest along their anterior arms; setae on the upper body arise from small swellings or tubercles that are variable in size. *Caripeta* spp. overwinter as pupae.

C. divisata *Wlk.* — *Tsuga heterophylla, Pseudotsuga menziesii, Picea,* all native spp., *Abies lasiocarpa, A. grandis, A. amabilis, Larix occidentalis,* and occasionally on *Pinus monticola, P. contorta* and *Thuja plicata;* a generally distributed species south of latitude 56°; some years it is numerous. LARVA: head pale brown with dark herring-bone markings; body yellowish and grey or brown; interrupted off-white or yellow subdorsal stripes, sometimes obscure; elongate yellow, occasionally whitish, black-edged intersegmental patch anterior to and encompassing each abdominal spiracle; spiracular stripe may be continuous, may in part be suffused with reddish brown; broken yellowish subventral stripes; tubercles prominent; tubercles *ii* on central abdominal segments, b l a c k and yellow.

C. aequaliaria *Grt.* — *Pseudotsuga menziesii, Pinus ponderosa, P. contorta* (4 records), *P. monticola* (2), *Tsuga heterophylla* (2); Southern B.C. and Southern V.I., much less numerous than *divisata.* LARVA: of dark pigmentation; little whitish or yellowish colour along spiracular area; brownish about the abdominal spiracles.

C. angustiorata *Wlk.*—*Pinus contorta*; Central B.C. and Southern interior B.C. LARVA: grey or reddish brown; one specimen with high proportion of black; dorsal stripe usually yellowish; irregular yellowish pleural fold; central abdominal spiracles each narrowly encircled by an unpigmented ring; tubercles *ii* on central abdominal segments black; obscure transverse ridges between tubercles *ii*.

[1] Contribution No. 543, Forest Biology Division, Research Branch, Department of Agriculture, Ottawa, Canada.

[2] Forest Biology Laboratory, Vernon, B.C.
[3] Forest Biology Laboratory, Victoria, B.C.

Note on a Ground Beetle eating a new-born Field Mouse

This information was given me by Dr. James Bendell of the Department of Zoology.

In July 1958, Dr. Bendell was walking on the south side of the campus by a grassy roadside when he heard the shrill screams of a mouse. Upon locating the sound he found a **Microtus** or vole nest containing several blind suckling young, one of which was being chewed by a male **Carabus nemoralis** Müll. He capture the beetle and the mouse so there was no question as to their identity. The beetle had eaten the back of the thigh and the abdominal wall in the inguinal region so that the body cavity was visible. This beetle is normally a predator on earthworms.

—*G. J. Spencer, University of British Columbia, Vancouver.*

SPRAYING OPERATION FOR CONTROL OF THE BLACK-HEADED BUDWORM[1], VANCOUVER ISLAND, BRITISH COLUMBIA, 1957

R. R. LEJEUNE
Forest Biology Laboratory, Victoria, B.C.

During June, 1957, 196,000 acres of western hemlock on northern Vancouver Island, British Columbia, were sprayed to protect stands severely defoliated for two consecutive years by the black-headed budworm. These stands, out of a total outbreak area of about two million acres, were considered to be in critical condition. Surveys indicated that they could expect to receive damaging defoliation in 1957. Although it was dwarfed by the extensive control programs in the western United States and eastern Canada there are some special features about the project that are worth relating.

Organization

As this was the first large control operation attempted in British Columbia, an organization was needed to plan and direct the project and to provide a legal body for entering into commitments with governmental and private agencies. As a result the British Columbia Loggers' Association formed a permanent Pest Control Committee for this purpose. Representatives from the British Columbia Forest Service and the Forest Biology Laboratory serve on the Committee in an advisory capacity, but since this Association is composed of most of the logging companies in British Columbia, it can be considered that the project was directed by industry. The Forest Biology Laboratory was responsible for spray and biological assessment.

The Committee drew heavily on the experience acquired by other agencies in large-scale operations in the western United States and eastern Canada, but local conditions necessitated modification of some procedures followed elsewhere. We now have an organization and a soundly established pattern tailored to British Columbia conditions for handling future forest insect control problems.

Spray Equipment and Chemicals

The spraying was done by four converted TBM Gruman Avengers. This was the first time these aircraft have been used for spraying forests in Canada. They were selected because the rugged terrain, the radius of action, and the uncertain weather conditions likely to prevail indicated that a larger aircraft than the conventional Stearman was needed. In our opinion their performance with respect to pay load and spray pattern was impressive. As a result, several of these aircraft have been purchased by a Canadian firm and have been used against the spruce budworm in eastern Canada.

Since it was possible that the infestation could collapse at any time from natural causes, resulting in the cancellation of the operation, raw materials were stored and mixed as needed. Mixing and loading were done at the air base, where a mixing plant was constructed. The plant had a daily manufacturing capacity of about 30,000 gallons of spray and a storage capacity of about 35,000 gallons. Spray was loaded into the aircraft directly from the mixing plant.

The spray consisted of DDT in Standard base oil diluted with diesel oil to yield a solution containing 1 pound of DDT per U.S. gallon with an emulsifier content of 1.64 per cent. The emulsifier was Atlox 2082A. The use of an emulsifier in 1956 (Brown *et al.*, 1958) gave such satisfactory results that it was incorporated into the operational formulation in 1957.

Efforts were made to compare the effectiveness of the operational spray with three other formulations. How-

[1] Contribution No. 828, Forest Biology Division, Science Service, Department of Agriculture, Ottawa, Canada.

ever, in a pressing mixing and flying schedule it proved unpractical to exercise the precise control essential for experimental tests. Results indicated that as low as one-half pound of DDT per gallon per acre was as effective as the operational solution. Results with diesel oil without emulsifier were inconclusive and plans to experiment with water instead of an oil diluent were cancelled altogether.

Timing

Black-headed budworm larvae develop more slowly than spruce budworm larvae and therefore provide a longer period for effective spraying. In 1956 it was found that all the larval stages were susceptible to the spray. Spraying can be started when roughly 50 per cent of the larvae are in the second instar and, for maximum effect, should be completed before the appearance of fifth-instar larvae. In 1956 and 1957 this allowed a period of about one month for treatment. Spraying in 1957 commenced on June 10, and despite delays caused by poor weather, was completed on June 20.

Control Achieved

The operation achieved its principal objective (Lejeune *et al.*, 1957). Biological assessment plots showed that the budworm was completely controlled where the spray deposit was adequate (over 10 drops per cm.^{2} or .20 gal. per acre). Data obtained indicated that the spray deposit in general ranged from light to medium (1 to 20 drops per cm.^{2}). Deposits were lighter in areas skip-sprayed to avoid lakes, streams, cut-over areas and cedar swamps, and heavier where avoidance of specific landmarks was not required. The indicated average control of about 90 per cent, based on data from five sample plots, was sufficient to prevent serious defoliation in 1957.

Fish Mortality

When it was decided in the fall of 1956 to proceed with a spraying operation in 1957, it was anticipated that some commercial and game fish might be killed. Accordingly the decision was made known to the Federal and Provincial fisheries authorities, who were invited to have representatives at all subsequent meetings of the Committee.

In co-operation with the Committee, plans were drawn up by the fisheries organizations to assess mortality of fish and fish food organisms. The main concern was for the fry of cohoe salmon and steelhead trout, which would be in the streams during the spray period. To minimize contamination of waters, pilots were instructed to shut off the spray when flying over rivers and lakes, streams were not to be used as boundaries of spray blocks and, where feasible, pilots were to spray parallel to the course of major streams keeping one swath width away. Fisheries representatives, who were present on all flights made by the observation aircraft, were satisfied that a sincere effort was made to implement these measures, but spray drift hit some lakes and streams and fish were killed.

The effects of spraying were measured in nine of the ten major salmon streams in the area (Crouter and Vernon, 1959). Results obtained indicated a large variation in the mortality of cohoe fry, ranging from zero to almost complete annihilation. Losses were severe in four of the major streams, not only to cohoe but also to trout, steelhead yearlings, and possibly alevins of trout and steelhead.

The reduction of aquatic insects paralleled the loss of cohoe fry and the productivity of several streams may not return to adequate proportions for several years.

The effects of spraying varied with each stream but some trends were noted. Fish mortality was high in large streams in flat terrain with dense forest cover, which made the streams difficult to see from low flying aircraft, and in large streams flowing through steep-walled valleys. Mortality was low in streams in well-defined but not particularly steep-walled valleys and in small streams with a dense overhanging canopy.

In June, 1957, 156,000 acres of western hemlock were sprayed to control the black-headed budworm. The operational spray consisted of DDT in Standard base oil diluted with diesel oil to yield a solution containing 1 pound of DDT per gallon with an emulsifier of 1.64 per cent. Spray was applied at the rate of 1 gallon per acre. The indicated average control of about 90 per cent was sufficient to prevent serious defoliation in 1957. Fish populations, particularly cohoe fry, and fish food organisms in some streams were severely depleted.

Summary

Although there were a number of puzzling inconsistencies in results obtained from the assessment of fish mortality, it is clear that under the conditions of the operation, fish and fish food populations in some streams were severely depleted.

References Cited

Brown, G. S., A. P. Randall, R. R. Lejeune and G. T. Silver. 1958. Black-headed budworm spraying experiments on Vancouver Island, British Columbia. For. Chron. 34: 299-306.

Crouter, R. A. and E. H. Vernon. 1959. The effects of black-headed budworm control on salmon and trout in British Columbia. Canadian Fish Culturist 24: 23-40.

Lejeune, R. R., A. P. Randall and K. R. Elliott. 1957. Aerial spraying operations for control of the black-headed budworm, Vancouver Island, British Columbia, 1957. Interim Report 1957-1, Forest Biology Laboratory, Victoria, B.C. (Multigraphed).

THE DISTRIBUTION OF THE WHEAT MIDGE, SITODIPLOSIS MOSELLANA (Gehin), IN BRITISH COLUMBIA

J. C. ARRAND
A/Provincial Entomologist

The wheat midge, *Sitodiplosis mosellana* (Gehin), was first reported in the Pacific Northwest in 1904 at Chilliwack, B.C. Since that time it appears to have spread through the province. It was listed as an important pest of grain in the lower Fraser Valley in 1905. In 1921 serious damage was reported in the Salmon Arm district. A wheat field was damaged by this pest near Lumby in 1936 when there was also serious damage on Vancouver Island and in coastal districts. Light damage was recorded at Merritt in 1951 and at Nelson in 1953. In 1954 infestations were reported from Larkin, Armstrong and Enderby. Damage occurred on spring wheat at Revelstoke, Grindrod, Enderby and Salmon Arm in 1955.

In 1957 a heavy infestation was examined in a field of Garnet wheat at Kersely, south of Quesnel. According to the farmer this field had been similarly infested in 1956. In 1958 several fields were infested in the Kersely area and serious damage occurred. This infestation appears to be so severe that unless it subsides it is questionable whether the farmers in the area can continue profitably to grow grain. The farmers report that fall wheat and barley as well as spring wheat have been attacked. In the literature, these grains as well as oats are listed as hosts of the pest.

Since the wheat midge has become so well established at Kersely, it seems reasonable to assume that it may eventually move into the Peace River area.

References

Reeher M. M. 1945. The Wheat Midge in the Pacific Northwest. U.S.D.A. Circ. 732.
B.C. Dep't. of Agriculture Annual Report—1921, 1936, 1951, 1953, 1954, 1955, 1957, 1958.

AN IMPROVED TECHNIQUE FOR PINNING, SPREADING AND MOUNTING MINUTE LEPIDOPTERA[1]

J. K. HARVEY
Forest Biology Laboratory, Vernon, B.C.

Methods of spreading minute Lepidoptera vary greatly, and results are frequently poor. There is no satisfactory board manufactured for spreading their wings, therefore one has been designed by the writer. This paper describes the spreading board and how it is used.

Construction of Spreading Board

Glue a strip of 2 x 14 x ¼ inch cork to a strip of plywood of the same dimensions. Cut a 1 x 14 inch strip of 1/32 inch thick patent leather lengthwise down the centre, using a straightedge and a sharp knife. Glue the two strips of patent leather 1/32 of an inch apart along the centre of the cork strip, smooth side up. (Fig. 1). It is convenient to make up three or more boards, varying the width of the groove for different sized moths.

Pinning and Spreading the Moths

The following equipment is used by the writer when preparing microlepidoptera specimens: spreading board, forceps, dental loop, minuten pins, glassine paper in 3/16 x ⅜ inch strips, hard balsa wood pieces ⅛ x ⅛ x ⅝ inches, number 3 insect pins and a standard mounting block.

1. Specimens to be spread must be thoroughly relaxed.

2. Place the moth venter side down on a balsa board. Grasp a minuten pin with a pair of forceps and insert the point perpendicularly through the centre of the thorax, until it penetrates 3/16 of an inch through the venter. The author wears a dental loop to expedite this work.

3. Grasp the top of the minuten pin with the forceps and push it vertically into the groove (which should be just wide enough to fit the insect's body) so that the body rests in the groove, and the wings rest on the board.

4. Very lightly blow the wings forward, separating the fore-wings from the hind-wings. Sometimes they can be blown into the desired position and will remain there without having to be anchored by a minuten pin.

5. Grasp a minuten pin with the forceps and, catching the forewing just behind the longitudinal main vein, close to the thorax, pull the wing forward over the surface of the board until the posterior margin of the hind fringe is at right angles to the body. Anchor it with the pin.

6. Bring the hind wing forward in the same manner until the fringe of the anterior margin is nearly touching the forewing fringe and anchor it.

7. Gently lay a strip of glassine paper lengthwise over the anchored wings, taking care not to disturb any wing scales. With the forceps, secure the strip of glassine paper with four minuten pins, two pins just forward and to the outside of the front wing and two pins just behind and to the outside of the hind wing. Repeat the procedure for the wings on the opposite side.

8. Gently remove the temporary anchoring pins.

9. Using a curved pointed 00 pin in a holder, ease the antennae into the desired position.

10. When the specimen is dry (usually two or three days under room conditions), remove the minuten pins while holding the glassine paper down with a pair of fine forceps.

11. When all anchor pins have been removed, lift the strips of glassine paper with forceps.

12. Using forceps, lift the spread moths from the spreading board.

Mounting the Moths

Hard balsa wood strips may be ob-

[1] Contribution No. 537, Forest Biology Division, Science Service, Department of Agriculture, Ottawa, Canada.

tained in ⅛ x ⅛ x 18 inch strips. Cut these into ⅝ inch lengths for mounts. Insert a number 3 insect pin vertically through the balsa mount 1/16 of an inch from one end. Press the mount to a height of ¾ inch on the pin, using the appropriate step on the "pinning block." With forceps, grasp the pin holding the moth and press the point 1/16 of an inch vertically into the balsa mount ⅛ of an inch from the end. The mounted specimen is then ready for labelling. (Fig. 2).

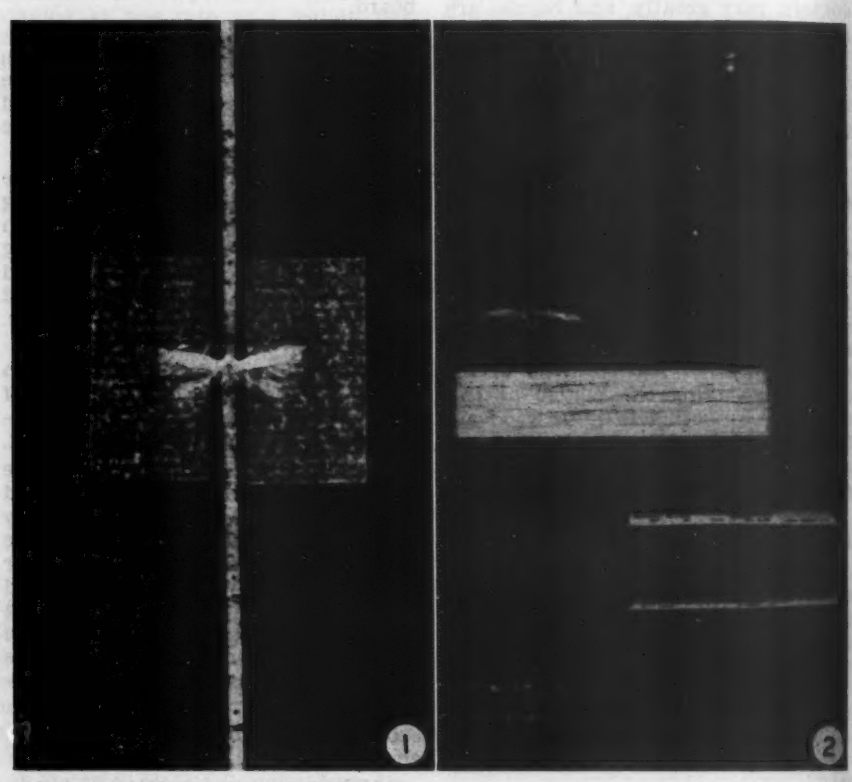

Fig. 1. Moth on spreading board.
Fig. 2. Mounted and labelled moth.

Pine Siskins Killing Forest Tent Caterpillars

In June 1954 the trembling aspen woodlands along the Fraser River Valley south of Quesnel, British Columbia, were denuded by an outbreak of the forest tent caterpillar, **Malacosoma disstria** Hbn. On June 22 in the semi-open country about Castle Rock, flocks of pine siskins, **Spinus pinus** (Wilson), were numerous and two instances of predation upon the fully-grown larvae were observed. The bird carried a larva to a suitable branch, then standing on the insect's body, grasped the head in its bill and pulled until the viscera were removed. These were laid along the branch and a small portion of the body contents were selected and eaten. One siskin killed three larvae in this manner in a few minutes.

—*J. Grant, Forest Biology Laboratory, Vernon, B.C.*

AN AUTHENTICATED CASE OF BLACK WIDOW BITE

G. CLIFFORD CARL[1] AND A. W. PERRY, M.D.[2]

In recent years there have been several reported instances in the Victoria area of humans being bitten by Black Widow spiders but in each case, except one, the causative agent was not positively identified. In fact in one instance the victim could not be sure that it was a spider that inflicted the wound and on another occasion it was fairly definitely determined later that the patient received nothing more than a prick from a raspberry cane!

The one known exception involved an eight-year-old boy whose case received some newspaper publicity in April 1950. The spider was apparently identified as a Black Widow but no record of the case has been published.

Another authenticated case of a Black Widow spider bite occurred in Victoria in 1958. The spider was seen immediately following the attack and it was subsequently captured thus permitting positive identification. The victim was a 16-year-old girl admitted to the Royal Jubilee Hospital Emergency Department at 4:15 a.m. on September 9, 1958, suffering with severe abdominal pain. The following is a copy of the case history:

"She had retired on the previous evening feeling well and had wakened at around 3:30 a.m. because of the sensation of a sharp needle-like pain in her right outer lower leg just above the ankle. Pulling her bed covers aside she saw a black spider scurry away. This pain passed off, but was replaced in about fifteen minutes by a severe aching pain in the right groin. This continued, but in turn was replaced in about ten minutes by excruciating generalized abdominal pain of a cramping nature and she was rushed to hospital.

Physical Examination

When seen shortly after her arrival she appeared apprehensive. Her face was slightly flushed and she was perspiring. She was restless, moving about the stretcher and almost in tears with pain in the abdomen. There was no pain in her leg or groin.

Pulse 90, regular. Blood pressure 140/70. Heart sounds were normal.

The abdomen showed a board-like rigidity. There was muscular but not deep tenderness so that it was apparent that the pain was arising from the abdominal wall rather than from the peritoneal cavity. No abnormality was seen or palpated in the right groin. The right leg showed a small red mark on its lower outer aspect. This could easily have been missed if the girl had not indicated its site. There was no redness or induration at all surrounding the small central red area. The reaction was not even that seen with a mosquito bite.

Treatment and Progress

It was apparent that her symptoms were due to the bite of a black widow spider. She was given intravenously 10 cc of 10% calcium gluconate a few minutes after her arrival. An ice bag was placed over the site of her bite and a hot water bottle to her abdomen. This resulted in a considerable decrease in her abdominal discomfort and she quietened down considerably but a half hour later it was necessary to give her 1/6 gr. of Morphine subcutaneously and a repeat injection of 10 cc of 10% calcium gluconate intravenously. This resulted in considerable relief of her distress. She was given 1,500 units tetanus antitoxin and antihistamine was commenced (Chlortripolon 4 mg. q.6.h.). During the first 24 hours she was quite miserable with profuse perspiration and the abdominal discomfort was replaced ten hours after admission by an aching in the transverse arches of her feet. She developed no fever and her blood pressure stayed stable. Her

[1] Director, Provincial Museum, Victoria, B.C.
[2] Medical Specialist, Victoria, B.C.

pulse ranged from 90 to 110. She did not void during the first 24 hours and during this period of time it was necessary to give her one further injection of 10 cc of 10% calcium gluconate and three further injections of Morphine gr. 1/6 and two aspirin and Codeine (gr. ½) capsules.

Between the 24th and 48th hour after admission her condition improved. She voided freely. A general urinalysis was negative. The abdominal pain disappeared, but the ache in the feet remained, and the soles of her feet were quite sensitive.

Hyperreflexia was noted at this time and she continued to have a moderate degree of perspiration with chilly sensations but no fever.

On the third hospital day her symptoms disappeared. On the fourth day she was discharged asymptomatic. Examination at this time revealed a soft abdominal wall and normal tendon reflexes.

Final Diagnosis

Black Widow Spider Bite (Arachnoidism).

The Black Widow spider is found in the dry regions of the Province usually in rubble heaps or under rocks. It is locally common in the Okanagan Valley and extends its range west at least as far as Princeton. Some years ago it was abundant in the vicinity of Trail (see The Black Widow Spider by K. Raht, Rept. Prov. Mus. for 1943, p. 13 and also Publication No. 127, by Fergus J. O'Rourke, Canada Department of Agriculture, Science Service, 1953). On Vancouver Island it is relatively common in the Victoria area and is found along the east coast as far as Nanaimo. On the mainland it has been collected at Powell River which seems to be an unusually wet place for this species.

In the southern United States this spider is said to be much more venomous yet fatal cases affecting man are rare.

ACHAETONEURA DATANARUM REARED FROM ANTHERAEA POLYPHEMUS IN BRITISH COLUMBIA (Diptera: Tachinidae)

HUGH B. LEECH

California Academy of Sciences, San Francisco
and

SINCLAIR H. FARRIS

Forest Biology Laboratory, Victoria, B.C.

A larva of *Antheraea polyphemus* (Cramer) was observed feeding on *Betula occidentalis* at Vernon, B.C., in July, 1945; it spun its cocoon in mid-August. The cocoon was brought indoors on January 30, 1946, and placed in an incubator next day (72° F., 90% relative humidity). On February 19, sixteen dipterous larvae emerged from it and formed puparia. From March 4 to 7, seven male and nine female flies were recovered. They have been identified by Mr. A. R. Brooks as *Achaetoneura datanarum* (Townsend, 1892), a somewhat uncommon species.

A second cocoon, from Trinity Valley, B.C., was incubated from March 12 to April 8 inclusive. Fifteen dipterous larvae left it on April 8 and formed puparia. On April 20-22, eight males and six females of *A. datanarum* emerged (det. Brooks); one additional specimen was accidentally destroyed before sexing.

Both cocoons were rested on a support which was at a 45° angle in the rearing jar. In each case the fly maggots emerged from the valvular end, though in one instance this end was upward.

SOME PROBLEMS IN THE COMPILATION OF A COMPATIBILITY CHART OF ORCHARD SPRAY CHEMICALS FOR USE IN BRITISH COLUMBIA[1]

D. P. PIELOU[2]

This paper arises out of discussions that took place when the compatibility chart of spray chemicals for orchardists in the British Columbia interior was drawn up in 1957; I was secretary of the committee responsible for producing the chart. This chart has to be revised at intervals, though not necessarily annually, as new materials and new formulations are introduced, and so it is worthwhile trying to put on paper some of our thoughts as to the principles involved.

In this paper, therefore, the examples quoted relate almost solely to experience in British Columbia while the opinions expressed represent an attempt by the author to summarize his own conception of the substance of numerous discussions between members of the Summerland Entomology Laboratory and of other agricultural scientists concerned with fruit growing in British Columbia. A review and discussion based on a broader geographical basis, perhaps world-wide, and on a broader range of crops, would be most desirable. This, however, would represent a much more ambitious project than is intended here.

One of the first things to appreciate about "compatibility" in connection with spraying of pesticides, is that the word covers a number of criteria and that materials that are compatible according to one criterion, are not compatible according to another. Compatibility of spray material is not a relatively simple concept as is "compatibility" of rootstock and scion in horticulture.

Chemical Compatibility

Primarily, compatibility is thought of as chemical compatibility, e.g., if two chemicals react in such a way as to reduce the effectiveness of one or both, then the two chemicals are incompatible. Thus, if certain fungicidal copper compounds are mixed with lime-sulphur (a mixture of calcium polysulphides) copper sulphide is formed which is insoluble, and useless (37). However, in general, the changes that take place on mixing spray materials may be very complex and even purely chemical compatibility can turn out to be a complex matter. In practice, a spray chemical does not consist of one compound, but is a "formulation." The need for formulation arises from the fact that most of the newer miticides, insecticides and fungicides are insoluble in water (20) and water is the vehicle most commonly used in applying them. They may be, therefore, sold dissolved in organic solvents such as xylene to which a small amount of emulsifier, such as an alkyl aryl polyether alcohol, is added (36). When mixed with water in the tank of the sprayer, such a formulation forms an emulsion. Alternatively, the active ingredient may be mixed with a suitable finely-divided, inert carrier acting as an absorptive material because of the large surface area of the fine particles (for example, aluminum magnesium silicate) together with a small amount of wetting agent such as an alkyl phenyl ether of polyethylene glycol (6). The formulation is sold as a co-called "wettable powder" which, on mixing with water in the spray tank, becomes a suspension of limited stability that is prevented from settling mainly by mechanical agitation. Since the type of formulation influences the effectiveness of the pesticide (10) it is obvious that on mixing two formulations, the possibilities for chemical and physical reactions that will affect the performance of one or both of the pesticides are complex. Generally speaking, chemical compatibility is, in practice,

[1] Contribution No. 2, from the Regional Research Station, Canada Department of Agriculture, Summerland, British Columbia.

[2] Entomologist.

the compatibility of materials that are already mixtures. It is not so simple as saying that sodium chloride and silver nitrate are incompatible because the insoluble silver chloride is percipitated.

There is another problem—a practical one—of chemical incompatibility. Chemists may say definitely that two materials are incompatible because they decompose during or after mixing. However, in practice the rate of decomposition is exceedingly important. Thus, according to McArthur and William (25), parathion [*O,O*-Diethyl O-*p*-nitrophenyl phosphorothioate] breaks down extremely slowly when mixed with lime-sulphur in the laboratory. If a tankful of the mixture is sprayed without unreasonable delay, both materials are effective. On the other hand, malathion [S-(1,2-Dicarbethoxyethyl)-*O,O*-dimethyl phosphorodithioate] breaks down so rapidly in lime-sulphur that only 25 per cent of the malathion remains as such approximately one hour after mixing (25). From the grower's point of view, as well as the chemist's, these two materials are incompatible. All so-called organic phosphates will, in time, break down in alkaline solutions like lime-sulphur, but it is the rapidity of breakdown that is important.

Malathion deserves further mention. It hydrollyses very easily, not only in alkaline solution but even in acid, and, to some extent, in water (20). In the presence of iron the hydrolysis is catalysed to such a degree that malathion emulsion must be sold in glass, and not in iron containers (20). The ease of hydrolysis makes production of wettable powders of malathion particularly difficult. This is why malathion is an expensive material to formulate as a wettable powder and costs more than parathion. The emulsion form in glass bottles is generally cheaper.

Mention should also be made of nicotine as used in British Columbia. Nicotine sulphate is acid, and, on most charts therefore, indicated as compatible with organic phosphates. However, it was found that, under conditions of the British Columbia interior, nicotine sulphate could be made a more effective aphicide by the addition of sodium carbonate, which reacts with nicotine sulphate to release free nicotine. At temperatures above 70°F., and particularly when applied as a concentrate spray by an air-blast machine, nicotine is extremely toxic to aphids (23). However, nicotine sulphate-sodium carbonate mixture is alkaline and should not be used with organic phosphates or with other pesticides that break down in alkaline solution (25).

Some of the so-called minor elements—zinc, manganese, magnesium, boron—can be applied as dissolved salts with an orchard sprayer to nutrition-deficient trees. Soluble dinitro compounds such as sodium dinitro-*O*-cresylate, if added to such salts, tend to react to produce insoluble metallic compounds that are unavailable to the plant and are but slightly toxic to insects. However, the two types of materials are not applied at the same time (2).

This brings up a point for discussion. Why express an opinion on the compatibility of two materials that should never be applied at the same time? Some comprehensive charts show compatibilities, or otherwise, of highly unlikely mixtures. We feel it is better to discourage the grower from wasting money and risking damage from the use of such mixtures by indicating that the two materials are not normally applied together.

Phytotoxic Incompatibility

When some pesticides are mixed, no chemical change may take place that reduces the effectiveness of the ingredients, but the mixture may cause damage to the plant. This is often a physical phenomenon in that the solvent, or adjuvant, in one formulation may allow increased pentration of some component in the other formulation. Many oils, for instance, readily penetrate the underside of a

leaf particularly through the stomata (11) and so transport anything dissolved in them. Lighter oils will readily penetrate either leaf surface and twigs as well (40). It is not surprising, therefore, that many oils do damage to fruit trees (5) and the selection of suitable types of oils, for both dormant and summer spraying, occupied the attention of orchard entomologists for many years. Thus, summer oil can cause plant damage, and so can wettable sulphur, but a combination of the two is far worse than one would expect from a purely additive response. This effect of this particular combination is so marked (12) that some of our older spray calendars, published at a time when application of summer oil was more common, included a warning not to apply sulphur (or lime-sulphur) and summer oil, even separately, within a certain time in order to avoid spray injury (1). In place of the summer oil, any organic solvent from another formulation can act with sulphur in the same way. The high toxicity of DNOC [2-methyl-4, 6-dinitrophenol] is well known (5, 20) and, though it could be used by itself with care as a summer spray in orchards (26), it has not been so recommended because the presence of a very small amount of oil, as in spray-drift from a neighbors orchard (9), or the presence of slight oil residue from a much earlier spray application (29), will produce severe symptoms of phytoxicity. And oil or oil-like components in formulations of other pesticides act similarly on DNOC. Incidentally, such deep penetration of contact insecticides is, generally speaking, of little value insecticidally as most insects or mites, or their eggs, are on the surface of the plant.

We have, for instance, listed malathion as incompatible with dinitro compounds because malathion is marketed most cheaply as an emulsion, and the solvent in the emulsion allows the dangerous penetration of the dinitro compound. Malathion emulsion in combination with glyodin [2-Heptadecyl-2-imidazoline acetate] and captan [N-Trichloro-methylmercapto-4-cyclohexene-1, 2-dicarboximide] appears to be more phytotoxic than a purely additive response would imply. Sevin [N-methyl-1-naphthyl carbamate] and lime-sulphur are incompatible because, in alkaline solution, the former breaks down fairly rapidly to alpha-napthol (39) which is decidedly toxic to some apple varieties, although Sevin itself is not. There is also some slow breakdown of Sevin alone to alpha-napthol because of weathering and this has caused slight injury on some varieties of apple, e.g., McIntosh (39).

A somewhat similar case, though not of phytotoxicity, is the evidence (33) that tainting from lindane [1,2,3, 4,5,6-hexachloro-*cyclo*hexane] is accentuated in the presence of summer oil, added to increase the aphicidal properties (27), presumably a result of increased penetration.

On the other hand, damage with minor elements probably is rarely accentuated by incompatibilities for the damage is believed to be due to exosmosis and would take place with any strong salt on the leaf.

In some combinations that are prone to cause damage, for instance ovex [p-Chlorophenyl *p*-chorobenzenesulphonate] with malathion, or with ferbam [ferric dimethyldithiocarbamate], there is no evidence, considering the extent of the damage, that more than a purely additive response is involved (9). However, even in such a case, some warning to the grower is required. It seems unlikely that in a mixture of ingredients, all phytotoxic to some degree, overall phytotoxicity will be reduced.

Physical Incompatibility

An example of physical incompatibility arises in the mixing of lime-sulphur and dormant oil. If oil that is emulsified by a soap or soap-like compound is added to a solution of lime-sulphur, the calcium in the lime-sulphur reacts with the emulsifier to produce a calcium soap and may cause the emulsified oil to invert. In that case there will be an emulsion of water drops in oil instead of oil drops

in water; and, because the continuous phase is oil, the emulsion will float on top of the bulk of the water as a scum (19).

At this point, before considering other aspects of compatibility, it is worth noting that manufacturers seem to be conservative when describing the compatibilities of a new material. Though they may well tend to exaggerate its pesticidal potencies, they have nothing to gain by risking its being mixed in some deleterious combination that may merely bring their product a bad name. This means that the grower may have to make separate applications in order to avoid stated incompatibility and so he incurs unnecessary expense. However, from the manufacturer's point of view, a product is not usually sold on the strength of its wide compatibility; it is sold on reputed efficiency in killing disease organisms or insect pests. For instance, DDT is often stated to be incompatible with lime-sulphur, but the actual decomposition is so slow as not to be a factor.

Other Spraying Problems

The categories of incompatibility that have been lisited above are conventional ones, and the necessary information can generally be included in some way, in the conventional type of two-dimensional chart. There are, however, closely related problems of spraying which usually need to be dealt with at the same time, but which do not solely concern combinations of two or more spray materials. We can, if we like, stretch the word "incompatibility" to include these problems; but, whether we do or not, these problems should be discussed at the same time.

(a) Some questions arise from the use of a particular type of sprayer. We might refer to these as problems of "mechanical incompatibility." Thus, in the air-blast concentrate sprayer, difficulties of excess foaming sometimes arise, difficulties that do not arise in the old-type, high-volume, gun sprayers. For instance, Sulphenone [p-chlorophenyl phenyl sulphone] has to be applied at high rates for mite control (2, 7). As DDT [2,2-Bis(p-chlorophenyl-1, 1, 1-trichloroethane] and perhaps ferbam, are likely to be applied at the same time (2), the total quantities of emulsifiers and wetting agents in the tank are very large; excessive foaming is the result (25). The material, ryania (ground stems of *Ryania speciosa* Vahl.), has caused trouble simply by the concentration of solid suspension in the tank. For instance an application of ryania at 48 pounds per acre for codling moth control in British Columbia (28) meant that there were 48 pounds of insoluble and bulky powder in 80 gallons of water. DNOCHP [2,4-dinitro-6-*cyclo*hexyl phenol] formerly recommended for the control of several species of mites (1) is one of the few spray chemicals unsuited for concentrate application because of enhanced phytotoxicity (7). On the other hand, under some circumstances phytotoxicity is reduced by true concentrate application (i.e., no leaf drip as compared with dilute high-volume application for the same per acre amount of material (21, 23).

(b) "Seasonal Incompatibility". Many materials are safe at one stage of plant development, but liable to cause damage at another; dormant oils are an obvious example. Ovex is ovicidal at the pink bud stage, and in the summer, but because of the likelihood of fruit damage (8), can only be recommended in the former case. Other miticides such as Aramite [2-(*p*-tert.-Butylphenoxy)-isopropyl 2'-chloroethyl sulphite] are non-ovicidal and would be of little value in the early part of the season (7).

(c) "Weather Incompatibility". Dinitro compounds and lime-sulphur must dry quickly if injury is to be prevented. That, in fact, is the reason that lime-sulphur is applied in England by concentrate sprayer, completely undiluted (23). The general recommendation in British Columbia is not to apply lime-sulphur spray concentrate when leaves are wet (2).

In warmer climates, wettable sulphur can cause injury to many crops (19) and in British Columbia is like-

ly to do so to fruit-tree foliage during hot summers. For many years the spray calendar (1, 2) has contained a warning to this effect.

At high summer temperatures nicotine is a very effective aphicide but in cool weather it gives poor aphid control in orchards (21, 24, 34).

(d) "Crop and Variety Incompatibility". Some crops or varieties are particularly likely to suffer damage from a particular spray chemical regardless of whether it is combined with other materials. For instance, malathion is likely to damage cherry, either as a wettable powder or as an emulsion (34). Diazinon [O, O-Diethyl *O*-(2-isopropyl-4-methyl-6-pyrimidyl) phosphorothioate] is generally safe on cherry as a wettable powder, or an emulsion (31), but under the moister conditions of the Kootenay district, the latter has caused damage (38). Aramite is safe on apples but can cause damage on pears (2, 7). Pears, especially of the Anjou variety, are also more susceptible to injury from dinitrophenol derivatives than apples (26). Lead arsenate, once widely used on apples, is phytotoxic to peach and apricot (35). Maneb may be injurious to some varieties of apples, particularly Rome Beauty. Golden Delicious apple is susceptible to injury by many materials, for instance, by trithion [O, O-Diethyl *S*-*p*-chlorophenylthiomethyl phosphorodithioate] either as an emulsion or wettable powder (32). Fruit damage is a particularly important consideration because sales organizations demand a very high standard of finish and a freedom from blemish—a problem not met with in many other crops.

(e) "Geographical Incompatibility". This is perhaps a vague category because not only climate varies with geographical locality, but so do soil, orchard practices, varieties, times of application, species of pests and types of applicator. However, it is clear that some general differences are important. Thus, lime-sulphur and oil are applied regularly to peaches in California, but used in British Columbia the same mixture would cause damage (35) and is not recommended (2). Rapidity of drying in different localities may influence the choice of spray chemicals. Characteristic varieties in different localities may cause different materials to be regarded as safe or dangerous. In England, certain apple varieties including Worcester Pearmain and James Grieve (30), are seriously damaged by the mite ovicide, fenson [*p*-Chlorophenyl benzene sulphonate] in the pink bud stage (18). However, fenson is not injurious at the pink bud stage to common varieties of apple in British Columbia and is here regarded as less likely to cause damage than the somewhat chemically similar ovicide, ovex (8).

The preceding examples in this section are examples of difficulties arising from spraying that are not, strictly speaking, the result of incompatibility; but they emphasize that the grower must concern himself with all troubles associated with spraying, and incompatibility, as ordinarily defined, is one of these. The grower wants to know if he will get effective control and no damage from chemicals A or B; or from a mixture of A and B, irrespective of whether conventional conceptions of compatibility are involved. Therefore, along with a suitable local compatibility chart, there should be a brief summary of general and specific advice about dangers that are not apparent from inspection of the chart alone. This summary should be regarded as equally important to the chart. Without it a grower may be inclined to regard the chart as a complete guide to the dangers associated with spray mixtures; this it certainly is not.

Presentation for the Grower

When we have acquired all the data we think relevant, we are next faced with the problem of presenting the information to the grower. We do not think that a broad, comprehensive compatibility chart covering all crops, areas, and chemicals is of any great value. Such a chart must have so many reservations and warning categories as to be of doubtful value except in the most obvious cases. Moreover, a large compatibility chart cov-

COMPATIBILITY CHART
FOR SPRAY CHEMICALS USED ON TREE FRUITS IN B.C.
1958
✓ GENERALLY COMPATIBLE.
NO DO NOT USE TOGETHER. EITHER CAUSES DAMAGE, OR SPRAY IS INEFFECTIVE, OR REDUCED IN EFFECTIVENESS.
O WIDELY USED, OR LIKELY TO BE WIDELY USED, AS A MIXTURE; GENERALLY SATISFACTORY BUT DAMAGE OCCASIONALLY OCCURS.
A COMPATIBLE WHERE DNC IS USED FOR SPRAY THINNING, BUT DNC IS INEFFECTIVE FOR INSECT CONTROL IN THIS MIXTURE.
NOT APPLIED AT THE SAME TIME, OR ON THE SAME FRUITS, OR UNNECESSARY TO USE BOTH CHEMICALS.
DDT
DIAZINON
MALATHION
LINDANE
NICOTINE SULPHATE + WASHING SODA
FENSONE
ARAMITE
SULPHENONE
OVEX
DORMANT OIL
DORMANT OIL + DNC
DINITRO CRESOL SODIUM SALT
DNP
LIME SULPHUR
WETTABLE SULPHUR
BORDEAUX
FERBAM
ZIRAM
MANEB
DICHLONE
MANGANESE, BORON AND MAGNESIUM
KELTHANE

Fig. 1.—Compatibility chart of orchard spray chemicals for use in British Columbia.

ering many more chemicals than are used in British Columbia will merely confuse the grower; consequently, the chart, or charts, should be as simple as possible. In some fruit growing areas where many chemicals are in use, some simplification has been reached by issuing charts for each tree-fruit. This has been done, for instance, in New Zealand by Jacks and associates (14, 15, 16). Borden (4) in California produced a compact chart of reasonable size covering all tree-fruits and nuts, but consisting of two sections—one covering dormant and prebloom sprays, and the other post-blossom applications. Both the New Zealand and California charts covered a larger number of chemicals than are used in British Columbia. In addition to the charts for specific fruits, Jacks (13) also issued a booklet giving general warnings on incompatibilities for all crops.

Examination of the present British Columbia spray recommendations for orchardists (2), shows that 11 materials are listed for use as sprays on cherries, ten on prunes, eight on apricots, 16 on peach, and 19 on apples and pears. These, of course, include alternatives; only a few would be used by any one grower. All materials that can be applied to stone fruits can be, with only one or two exceptions, applied to apples. And in addition, almost all fruit growers in the British Columbia interior grow apples, though not all grow stone fruits. About five materials, not on the 1958 spray chart, are also in fairly common use. In view of the modest number of materials recommended in British Columbia, it was felt that one chart could cover all tree-fruits. Separate smaller charts for each stone fruit would not be justified because very few growers earn a living from one kind of stone fruit only.

A decided stand was taken to express no opinion on the compatibility of materials not used together, but to insert a symbol on the chart indicating "not applied at the same time, or on the same fruits, or unnecessary to use both materials". This approach should help the grower to avoid error and expense in the use of a wrong, or unnecessary material, and discourage him from using unusual mixtures that might damage his fruit.

The category "spray with caution" so prevalent on many comprehensive charts, we consider to be almost useless. If a grower could detect, within a few minutes of commencing to spray with some questionable combination, any plant injury or lack of pest control, and could thereupon discontinue his efforts, there might be some point in the warning. However, in practice, the effectiveness, or damage that results, is not, as a rule, apparent until several days later. When there is reasonable likelihood of damage, we feel that the materials should be listed as incompatible. Now that rapid application by concentrate sprayer (23) is common it is then well worth the grower's time to put on separate spray applications rather than risk damage. On the rare occasions when a grower might be likely to use a doubtful mixture and take a calculated risk, the possibility of damage would be indicated.

A compatibility chart based on considerations of this kind was issued in 1957 (3). Since then, a few extra materials have been added to the list and the extent of the use of others enlarged. A modified chart incorporating these recent changes is shown in Fig. 1. In this chart all currently recommended spray materials are listed. In addition, older materials, though not recommended but widely used, are also included. Obsolete materials still used by a few growers are not listed, nor is the highly toxic compound, parathion, though it is quite commonly applied. As it is the firm, if unique, policy in British Columbia not to recommend highly toxic materials (21) particularly because of dangers to human beings in the typically small orchards and in home sites, it was considered that nothing further should be done to apparently sanction the use of such materials.

General Advice on Spraying and Compatibility

Under the heading "Information on

Compatibility, Spray Damage and Related Problems", information, of the type mentioned earlier that covers points not apparent from the chart, was noted on the back of the chart issued in 1957. Since then a number of omissions have been noted. The following items of information, and recommendations for growers, are suggested for the next chart to be issued:—

1. Lack of "compatibility" may be apparent in several ways. Combinations are incompatible (a) if they cause damage when the separate ingredients do not (b) if the combination causes a reduction of effectiveness of either ingredient (c) if there are other troubles such as excess foaming in the tank, or breaking of an emulsion, that make spraying difficult.
2. Almost all spray materials may, under unfavourable conditions, cause injury.
3. Unrecommended combinations may sometimes be harmless or satisfactory. They may also be disastrous.
4. Some spray materials are prone to cause injury; in a combination this may be confused with incompatibility.
5. Under British Columbia conditions, emulsions or solutions are generally more likely to cause damage than wettable powders. In combinations this tendency may be increased.
6. Liquid surface-active adjuvants or "surfactants" (in excess of the normal adjuvant in an emulsion or wettable powder), added by growers to spray concentrates to improve finish and effectiveness, are likely to accentuate injury from materials that are themselves prone to cause injury; or if spraying is continued, to dripping; concentrates containing ferbam, malathion, DNOCHP, or lime-sulphur are particularly suspect in this connection.
7. Once a tank of spray material is mixed, apply as soon as possible.
8. Do not spray potentially harmful materials when foliage is wet.
9. Spray in still air if possible.
10. Excess foaming may occur in the tank if several materials are mixed, as each may contain a highly-foaming wetting agent. Certain types of wettable sulphur are liable to foam excessively in concentrate sprayers.
11. Dormant oil may cause injury to fruit buds if applied too late, and particularly if improperly emulsified or double-sprayed. Application in windy conditions may result in double spraying.
12. Malathion should not be used on cherries. On other fruits, a wettable powder is less likely to cause injury alone, or in mixtures, than are liquid formulations. Malathion decomposes very rapidly in alkaline solutions such as lime sulphur, and becomes ineffective.
13. Nicotine sulphate should always be used with washing soda for maximum effectiveness in concentrate spraying. This is a basic, not acid, mixture and incompatible with many other materials. Most compatibility charts refer to the use of nicotine sulphate alone; it is acid, and behaves differently.
14. Nicotine should not be applied at temperatures below 70°F. or ineffective control may result.
15. Lindane is not now recommended because of its tendency to taint fruit, especially processed fruit.
16. Aramite should not be used on pears*.
17. DNOCHP should not be applied (a) with concentrate sprayers (b) to pears until four weeks after the calyx stage (c) to apples until two weeks after the calyx stage (d) with summer oil or after oil (e) with added surface-active adjuvants. DNOCHP may react with basic or metallic compounds.

*This was the recommendation up to 1958. Because of a possible carcinogenic hazard, the Canadian Food and Drug Directorate prescribed, early in 1959, a legal residue tolerance of zero for Aramite. Aramite is not now recommended at all in British Columbia.

18. Lime-sulphur should not be applied as a concentrate when trees are wet, or in damp weather.
19. Ovex and fenson should not be applied after the pink bud stage to any fruit.
20. Maneb can cause injury to apples of the Rome, Cox's Orange and Wagener varieties.
21. Ferbam leaves a more objectionable residue than ziram. Husk fall application of ferbam to stone fruits must not be delayed or unmarketable fruit may result from discoloration.
22. The information presented in the chart refers to two-ingredient sprays. If three or more ingredients are mixed, unpredictable incompatibilities may occur. The more materials there are in the tank the greater is the probability of trouble.
23. Do not exceed recommended speeds when using a concentrate machine.
24. "Semi-concentrate" spraying is more dangerous than concentrate spraying. Contrary to popular opinion "semi-concentrate" spraying, i.e., from 90 to 250 gallons of spray liquid per acre, is more likely to result in spray injury than true concentrate spraying, i.e., less than 75 gallons per acre, from a similar machine. That is because "semi-concentrate" spraying results in extensive dripping and, with spray materials several times stronger than in gun spraying, injury is likely to occur at the point of drip on leaves or fruits. If a concentrate sprayer is properly designed and adjusted there is no drip at an output of 75 gallons per acre or less.
25. Improper adjustment of concentrate sprayers can cause damage. It is most important that concentrate sprayers have air volume and air velocity adequate to spray the tops of trees without overspraying the bottoms of the trees. Overspraying with a true concentrate sprayer can be recognized by the occurrence of drip. Sometimes overspraying is the result of wrong nozzle arrangement and sometimes of worn orifice discs or swirl plates. Nozzles should be adjusted so that about 75 per cent of the spray liquid is in the upper half of the air stream.

References

1. Anonymous. Control of tree-fruit pests and diseases. British Columbia Dept. Agr. poster. 1948.
2. Anonymous. Control of tree-fruit pests and diseases. British Columbia Dept. Agr. poster. 1958.
3. Anonymous. Summary of annual reports, Science Service and Experimental Farms Service, Summerland, B.C. 1956: 9-12. Canada Dept., processed pamphlet (1957).
4. Borden, A. D. Incompatibility chart of spray chemicals. Western Fruit Grower, February: 32-33. 1956.
5. Brown, A. W. A. Insect control by chemicals. John Wiley and Sons. New York. 1951.
6. Carbide and Carbon Chemicals Company. Tergitol surface active agents. Pamphlet. New York. 1956.
7. Downing, R. S. Acaricide trials in British Columbia orchards. Proc. Ent. Soc. British Columbia 47: 1-4. 1951.
8. Downing, R. S. Recent trials with new acaricides in British Columbia orchards. Can. J. Plant Sci. 38: 61-66. 1958.
9. Downing, R. S. (Personal communication). Entomology Laboratory, Summerland, B.C.
10. Ebeling, W., and R J. Pence. Pesticide formulation. Influence of formulation on effectiveness. J. Agr. Food Chem. 1: 386-397. 1953.
11. Ginsburg, J. M. Penetration of petroleum oils into plant tissues. J. Agr. Research 43: 469-474. 1931.
12. Harman, S. W., and J. B. Moore. Further studies with lead arsenate substitutes for codling moth control. J. Econ. Ent. 31: 223-226. 1938.
13. Jacks, H. Incompatibility of spray materials. Supplement to Orchardist of New Zealand, 28 (8). 1955.

14. Jacks, H., and J. E. Hawkins. Compatibility of spray materials used in New Zealond on apricots—1955. Orchardist of New Zealand 28 (3): 32. 1955.
15. Jacks, H., and R. E. Robbins. Compatibility of spray materials in New Zealand on pears—1954. Orchardist of New Zealand 28 (1): 17. 1955.
16. Jacks, H., and H. W. Rosser. Compatibility of spray materials used in New Zealand on peaches—1955. Orchardist of New Zealand 28 (4): 16-17. 1955.
17. Kagy, J. F. Toxicity of some nitro-phenols as stomach poisons for several species of insects. J. Econ. Ent. 29: 397-405. 1936.
18. Kirby, A. H. M., and W. H. Read. The toxicity of phenyl benzene sulphonate and some chlorinated derivatives towards eggs of certain tetranychid mites. J. Sci. Food Agr. 7: 323-330. 1954.
19. Martin, H. The scientific principles of plant protection. 3rd ed. Edward Arnold & Co., London. 1940.
20. Martin, H. Guide to the chemicals used in crop protection. Third edition. Canada Dept. Agr., Ottawa, Ontario. 1957.
21. Marshall, J. Trend and practice in control of orchard insects. Ann. Rep. Oregon Sta. Hort. Soc. 45: 15-17. 1953.
22. Marshall, J. What constitutes good concentrate spraying. Ann. Rep. Oregon Sta. Hort. Soc. 48: 145-149. 1956.
23. Marshall, J. Concentrate spraying in deciduous orchards. Canada Dept. Agr. Pub. No. 1020. Ottawa, Ontario. 1958.
24. Marshall, J. (Personal communication). Entomology Laboratory, Summerland, B.C.
25. McArthur, J. M., and K. Williams. (Personal communication). Chemistry Laboratory, Summerland, B.C.
26. Morgan, C. V. G., and J. Marshall. Dinitrophenol derivatives as summer acaricides in British Columbia. Sci. Agr. 29: 191-199. 1949.
27. Morgan, C. V. G. Influence of oil on toxicity of benzene hexachloride. Canadian Ent. 79: 109. 1947.
28. Morgan, C. V. G., and N. H. Anderson. Some aspects of a ryania glyodin spray schedule in British Columbia apple orchards 1. Entomological, horticultural and economic aspects. Can. J. Pl. Sci. 37: 423-433. 1957.
29. Morgan, C. V. G. (Personal communication). Entomology Laboratory, Summerland, B.C.
30. Murphy Chemical Company. Summer ovicides for the control of red spider mites. Pamphlet. Wheathampstead, England. No date.
31. Pielou, D. P., and M. D. Proverbs. Diazinon—a summary of recent work on a new orchard insecticide. Proc. Ent. Soc. British Columbia 55: 3-6. 1958.
32. Pielou, D. P., and R. S. Downing. Trithion as an orchard insecticide. Proc. Ent. Soc. British Columbia 55: 17-23. 1958.
33. Proverbs, M. D., compiler. Effect of benzene hexachloride on the odour and flavour of fruit. Canada, Dept. Agr., Sci. Serv. Res. Notes Ser., Ent., No. E-1. 1948.
34. Proverbs, M. D. Chemical control of aphids in British Columbia orchards. Proc. Ent. Soc. British Columbia 51: 23-30. 1954.
35. Proverbs, M. D. Chemical control of the peach twig borer, **Anarsia lineatella** Zell. (Lepidoptera: Gelechiidae) in the Okanagan Valley of British Columbia. Proc. Ent. Soc. British Columbia 51: 31-36. 1954.
36. Rohm & Haas Company. Triton surface-active agents. Pamphlet. Philadelphia 5, Pa. 1951.
37. Shepard, H. H. The chemistry and action of insecticides. McGraw-Hill, New York. 1951.
38. Swales, J. E. (Personal communication). British Columbia Dept. Agr., Creston, B.C.
39. Union Carbide Chemicals Company. Sevin insecticide. Pamphlet. New York. 1958.
40. Young, P. A. Penetration, distribution and effect of petroleum oils on apple. J. Agr. Res. 49: 559-571. 1934.

A Solpugid in British Columbia

A couple of specimens of this near relative of spiders were given me some years ago by a student from southern Alberta. In these animals the head is distinct from the rest of the body and their classification depends upon the teeth in the upper part of the mandibles of the males. On February 14, 1958, Mr. W. Preston, R.R. No. 1, Oliver, in the South of the Okanagan Valley, brought me a solpugid which he had collected in June 1956 near an irrigation ditch. It is a female and so cannot be classified. I think this is the second record of a solpugid being taken in British Columbia. Mr. Jim Grant of Vernon, informed me that Dr. Kurata of the Royal Ontario Museum had reported them some years ago.

—*G. J. Spencer, University of British Columbia, Vancouver.*

CONTROL OF APHIDS AND CATERPILLARS ON BRUSSELS SPROUTS IN BRITISH COLUMBIA

A. R. FORBES AND H. R. MACCARTHY

Research Station, Canada Agriculture, c/o The University of British Columbia, Vancouver, British Columbia[1].

The cabbage aphid, *Brevicoryne brassicae* (L.), is a serious pest of brassica crops in British Columbia. The recommended control measures with malathion and TEPP have not always been satisfactory, especially on Brussels sprouts, broccoli, and cauliflower. With new and potentially useful systemic and contact insecticides available or about to become available it was necessary to work out new recommendations. This paper reports the results of exploratory field tests conducted at Vancouver in 1958.

Brassica crops are also attacked each season by other pests, which were considered when evaluating the insecticides against cabbage aphid; these were: imported cabbageworm, *Pieris rapae* (L.), diamond-back moth, *Plutella maculipennis* (Curt.), cabbage looper, *Trichoplusia ni* (Hb.), and green peach aphid, *Myzus persicae* (Sulz.).

Methods and Materials

Brussels sprouts was used as the test crop since it presented the most difficult problem in control under B.C. conditions. The aphids get into the sprouts where they are shielded from sprays and dusts. It lends itself well to continuing appraisal of leaves and of the harvested product. This crop also has a long growing period and must be protected until harvest is complete, which may be in November or even later.

Cultural procedures followed those of commercial growers as closely as possible. The variety of Brussels sprouts used was Long Island Improved, the one most commonly grown in the area. Plants were started in the seedbed May 8 and transplanted to the field June 12. The seedbed and the plants at transplanting were treated with heptachlor dust to control root maggots.

Eight treatments and the check were replicated 4 times in randomized blocks. Each plot consisted of two rows of 10 plants each. Table I shows the insecticides, formulations, rates per acre per application, and dates of application. Di-syston granules were applied to the soil around the base of the plants, but the other insecticides were applied as sprays at the field scale rate of 100 gallons per acre with a compressed air sprayer. The method of spraying gave results similar to those that would have been obtained in field applications: the spray nozzle was directed above and beside the plants but the rate did not permit individual spraying of each plant or thorough coverage of the lower leaves, especially the undersides. The surfactant Triton B 1956 (Rohm & Haas Co., Philadelphia 5, Pa.) was added to each spray at the rate of 4 ounces per 100 gallons. Portable barriers (figures 1 and 2) were placed around the plots during spraying. These were made of 1 x 4 inch cedar with corner braces, and covered with sign cotton cloth as used for advertising.

Di-syston was first applied when the aphids appeared in the field. The first application of all other materials was on July 30, when there were 194 colonies of *B. brassicae* on 60 leaves, i.e. when the infestation was well established.

Counts were made 14 times at weekly intervals from August 8 to November 14 from an upper, a middle, and a lower leaf from each of 5 plants at random per plot. Data recorded were: numbers of colonies of cabbage aphids, numbers of adult green peach aphids, numbers of each of the 3 species of caterpillars, and estimates of the percentage of leaf surface dam-

[1]Contribution No. 12.

TABLE 1.—Treaments against cabbage aphid on Brussels sprouts at Vancouver, B.C., 1958.

Insecticide	Toxicant per acre, per application lb.	Treated
None — check	—	—
TEPP[1] 20% emulsion	0.25	July 30, Aug. 12, 25, Sept. 5, 15, 22
malathion[2] 57% emulsion	1.25	July 30, Aug. 12, 25, Sept. 5, 22
Thimet[2] 47.5% emulsion	1.00	July 30, Aug. 18, Sept. 15
N.A. Cyanamid 12,880[2] 46% soluble conc. (Dimethoate)	1.00	July 30, Aug. 25
N.A. Cyanamid 18,706[2] 25% soluble conc.	1.00	July 30, Aug. 18, Sept. 15
Di-syston[3] 5% granules	1.00	July 7, 30, Sept. 2
Systox[3]	0.50	July 30, Aug. 25
Phosdrin[4] soln.	0.45	July 30, Aug. 12, 25, Sept. 8, 22

[1] Later Chemical Co., Vancouver 14, B.C.
[2] Cyanamid of Canada Ltd., Toronto 5, Ont.
[3] Chemagro Corp., New York 16, N.Y.
[4] Shell Oil Company of Canada, Toronto 1, Ont.; 12.3 lbs. of toxicant per gallon.

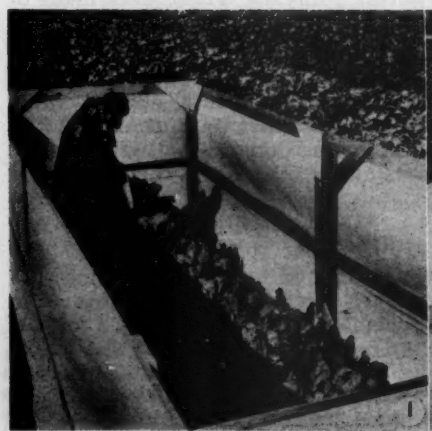

Fig. 1.—Portable barriers around plot during spraying.

Fig. 2.—Portable barriers being assembled around plot.

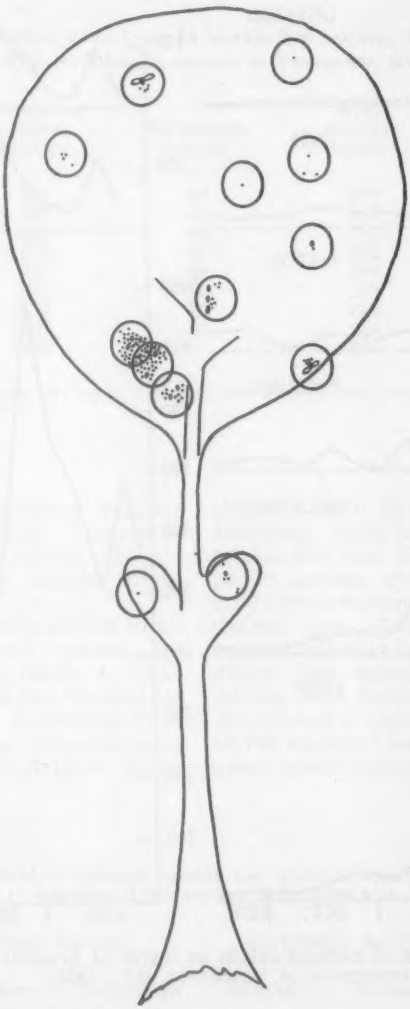

Fig. 3.—Diagram of mature leaf of Brussels sprouts with typical mid-season population of cabbage aphids. This leaf has 13 colonies.

aged by caterpillars. Where cabbage aphids covered large areas of the leaves, as in the checks, a circular area of covered leaf one half inch across, as estimated by inspection, was counted as one colony. A cabbage aphid in isolation, apterous or alate, settled on the leaf was also counted as one colony (figure 3).

At harvest 10 mature sprouts were taken, one from each of 10 plants per plot, every week for 7 weeks. These were weighed, inspected for caterpillar damage and examined by dissection for the presence of aphids. According to the absence or location of aphids they were categorized as clean, commercially acceptable, or rejected.

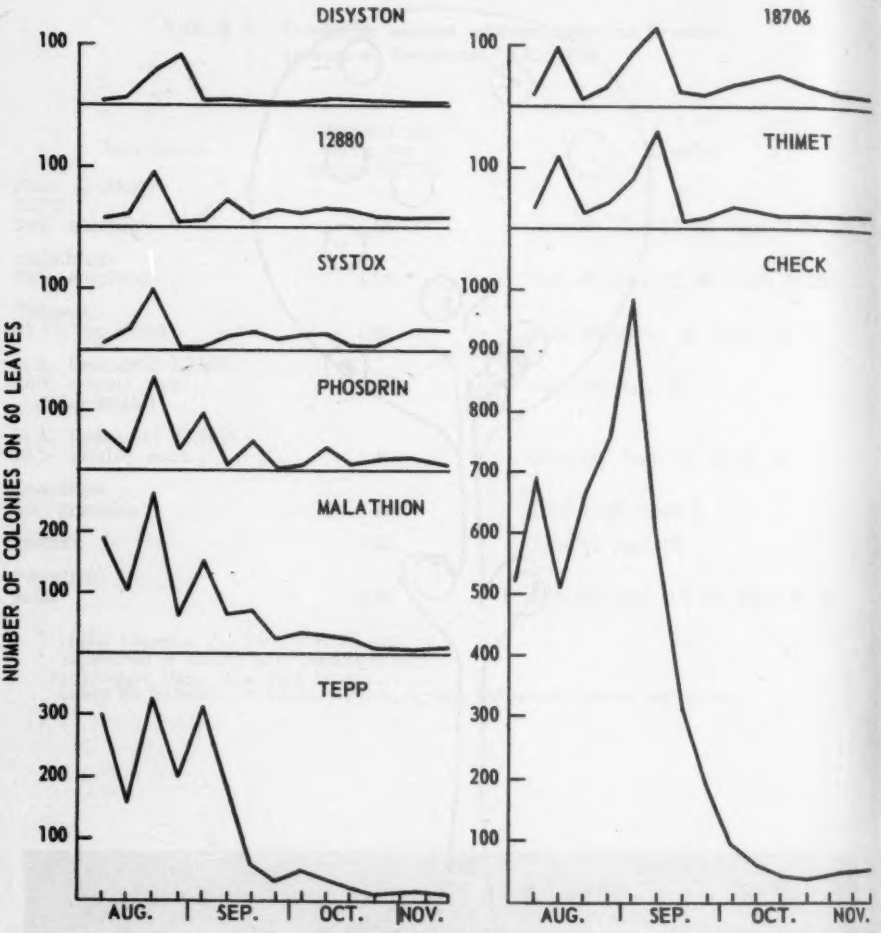

Fig. 4.—Populations of cabbage aphids on leaves of Brussels sprouts in all treatments at Vancouver, B.C., 1958.

Clean sprouts had no aphids in or on them; commercially acceptable sprouts had one or two aphids where they were easily washed off; rejected sprouts had aphids within the leaves where ordinary washing would not dislodge them. Differences between the treatments were assessed by analysis of variance.

Sprouts treated with Thimet, 12,880, 18,706, Di-syston, Systox, and Phosdrin were analyzed for residue by chemists of the British Columbia Research Council. Samples were taken from the field and immediately frozen on October 10 and 24. They were analyzed in February, 1959.

Results and Discussion

Aphids were first noted on the plants on July 7; by July 29 there were high populations of both cabbage and green peach aphids. The population of cabbage aphids in the check plots built up steadily until September 5 after which it declined (figure 4). A fungus infection, braconid parasites, syrphid larvae, chryso-

TABLE II—Aphid population totals from 14 weekly leaf counts[1], August 8 - November 14, 1958, on Brussels sprouts at Vancouver, B.C.

Treatment	*Brevicoryne brassicae* colonies	Percentage control	*Myzus persicae* adults	Percentage control
Di-syston	215	96	497	11
Systox	358	93	304	46
12,880	352	93	182	67
Thimet	538	89	283	49
Phosdrin	563	89	357	36
18,706	531	89	165	70
Malathion	1074	78	810	0
TEPP	1722	65	763	0
Check	4958	—	558	—

[1] Each weekly count from an upper, a middle, and a lower leaf from each of 5 plants per plot, 20 plants per treatment.

pid larvae, and cool damp weather contributed to the decline. The population of green peach aphids rose until August 15 but fell rapidly thereafter.

Populations of cabbage aphids in all treatments during the season are shown graphically in figure 4. Data on the effectiveness of the treatments against aphids are summarized in Tables II and III. The systemics gave markedly better control than malathion or TEPP. Di-syston was the outstanding material against cabbage aphids but had little effect on green peach aphids, probably because the latter were confined to the old leaves. Systox and 12,880 were promising against cabbage aphids. Phosdrin reduced the population of cabbage aphids each time it was applied but it required 5 applications. 12,880 and 18,706 were the best materials against green peach aphids.

TABLE III—Control of cabbage aphids and yield at harvest on Brussels sprouts at Vancouver, B.C., 1958.

	Clean Sprouts		Marketable Sprouts		Yield[2]
Treatment	Number[1]	Percentage	Number[1]	Percentage	gm.
Di-syston	59.0	84	68.0	97	1256
Systox	49.2	70	63.5	91	1236
12,880	48.7	70	61.5	88	1213
Thimet	45.2	65	60.5	86	1173
Phosdrin	43.7	62	58.5	84	1212
18,706	36.2	52	58.2	83	1146
Malathion	28.0	40	52.5	75	1233
TEPP	27.7	40	49.2	70	1121
Check	20.7	30	51.2	73	882
L.S.D. at 5% level	7.9		6.8		138
1% level	10.8		9.2		188

[1] Maximum of 70.
[2] Average weight of 70 sprouts.

TABLE IV—Percentage control of caterpillars on Brussels sprouts at Vancouver, B.C., 1958.

Treatment	Percentage control based on: Damaged sprouts[1]	Total caterpillars[2]	Leaves with more than 5% damage[2]	Undamaged leaves[2]
Phosdrin	76	87	44	24
Malathion	64	81	27	16
Thimet	34	61	22	6
12,880	21	56	25	11
TEPP	21	31	31	13
18,706	6	12	0	0
Systox	3	36	0	0
Di-syston	0	4	0	0

[1] Sample of 280 sprouts: 40 taken each week from October 2-November 14.
[2] Sample of 840 leaves: 60 taken each week from August 8-November 14.

All treatments greatly increased the yield of sprouts and there were no significant differences between treatments in this respect. The increases in weight ranged from 27 per cent for TEPP to 42 per cent for Di-syston. Thus controlling cabbage aphids increased both the yield and marketability of sprouts.

Against caterpillars, Phosdrin and malathion were the best materials (Table IV). Di-syston, 18,706, and Systox gave virtually no control.

TEPP and malathion were applied 6 and 5 times respectively, or every 7 to 13 days during the season, but never reduced the populations to acceptably low levels (figure 4). Other insecticides were reapplied each time the weekly counts of cabbage aphid colonies showed more than 50 per 60 leaves. Thus Phosdrin required 5 applications, Thimet, Di-syston, and 18,706 required 3, and 12,880 and Systox required only 2, to maintain the population levels shown (figure 4).

Green peach aphids occurred almost exclusively on the old, lower leaves. Over the 14 weeks, 0.5 per cent occurred on upper leaves, 3 per cent on middle leaves and 96 per cent on lower leaves. This and the fact systemics may not be effectively translocated to leaves that are not growing rapidly may account for their relatively poor performance. TEPP and malathion gave no control of green peach aphids because the method of spraying and rate of application did not permit coverage of the lower leaves.

The cabbage aphid occurred at all levels on the plant as follows: 19 per cent occurred on upper leaves, 37 per cent on middle leaves, and 44 per cent on lower leaves.

The method of counting aphids gave valid data on their relative numbers and their location. Results were consistent among different counters. For cabbage aphids, colonies were counted, since this is a gregarious species and the colonies provided discrete units that were counted easily and rapidly. For green peach aphids adults were counted, since this is a solitary species and the aphids are found dispersed over the leaf. Fortunately green peach aphid populations remained low so that counting the adults was not unduly time consuming.

The portable barriers used during spraying worked well in practice, so that buffer rows were not needed. They eliminated spray drift and permitted spraying even on windy days. The barriers were light and easily moved into position (figure 2).

No residue was detected in any of the sprouts except in those treated with Phosdrin and harvested on October 10. In these the inhibition of cholinesterase was 8.3 per cent greater than in the untreated check. The intervals in days, between last treatment and the October 10 harvest were: Thimet, 25; 12,880, 46; 18,706, 25; Di-syston, 38; Systox, 46; Phosdrin, 18.

PAINTED LADY, *Vanessa cardui*, on Vancouver Island

This cosmopolitan butterfly was common in Saanich, during 1958. Not since 1952 have I seen it in such numbers. As a matter of fact only a single specimen, in 1957, came to my notice between these dates. In 1958 I first noted it on May 18, and the last date recorded was October 1.

Soon after arriving in the district, from where I do not know, egg laying started on the two species of thistles abundant in the area, namely Canada thistle, *Cirsium canadensis*, and bull thistle, *C. lanceolata*. It seemed to prefer the latter. On June 18 I observed a female hovering about the head of a bull thistle where it was ovipositing so intently that it continued to lay even when I pulled the stem towards me for a closer look. In all, though not necessarily laid by this individual, 12 eggs were found, either on the involucre of the terminal flower head, or on the uppermost leaves just beneath the inflorescence. I snipped off the top of the plant containing the eggs and placed it under a muslin screen. The resulting caterpillars were reared to maturity. Adults emerged on July 17, one month after the eggs were laid.

During the course of the summer larvae in all stages of development were in evidence, varying from light yellowish green to almost completely black. Clumps of thistles soon assumed a bedraggled appearance, the bare leaf stalks festooned with the remnants of the silken cubicles in which the larvae lived or had lived. Pupae were rarely seen, however, as the caterpillars leave the food plant for less exposed quarters. Once in a while a chrysalis was found hanging within a very open-meshed tent along the leaf stalks of the host plant.

Fresh specimens of adults were common by July 18 and continued to be so well in September.

There is considerable overlapping of broods but with an average of one month for a complete life cycle and a constant succession of ova there could be two or more generations in one season, especially in a long, mild autumn as in 1958. From an economic point of view this is a useful insect, considering the ravages it commits among the thistles.

What becomes of the hosts of individuals seen up to October 1? They must do one of three things: Hibernate; but I have never come across them hereabouts, even early in the spring as in the case of the Mourning cloak and Angle Wing, both of which are known to hibernate. Emigrate; if so it is not noticeable. Or die before winter; here again I have no evidence in support of such a happening.

Most likely they are here in the first place as an overflow from Mexico or some other warm climate. They succeed well enough during the summer in their new haunt, but are unable to withstand the ensuing winter.

R. South in "The Butterflies of the British Isles" 1947 states that North Africa is thought to be the centre for this species, which periodically spreads all over the temperate world, where it thrives for a time but eventually disappears, until another wave of migrants from the original source re-populates its far flung range.

G. A. HARDY
Provincial Museum, Victoria, B.C.

THE SATIN MOTH, STILPNOTIA SALICIS (L.), IN THE INTERIOR OF BRITISH COLUMBIA

J. C. ARRAND
A/Provincial Entomologist

The satin moth, *Stilpnotia salicis* (L.) was first reported in British Columbia at New Westminster in 1920. This pest was probably introduced from Europe about 1918. Condrashoff (1957) reported that by the summer of 1955 it had spread northeast to Kamloops and then south into Vernon. By 1958 it appeared to be well established east of Shuswap Lake and south at least as far as Penticton.

The Forest Biology Laboratory at Vernon recorded it in 1958 from the following Points in the interior: Celista, Adams River, Shuswap, Pritchard, Salmon Arm, Canoe, Sicamous, Falkland, Armstrong, Vernon, Woods Lake, Duck Lake, Kelowna, Okanagan Mission, Lower Trout Creek, and Penticton.

In the interior the larvae of the satin moth have caused light to severe defoliation of trembling aspen, *Populus tremuloides* Michy; White or Silver poplar, *Populus trichocarpa* Torrand Gray; Lombardy poplar, *Populus nigra* L. var *italica* Muench; Carolino poplar, *Populus Eugenei* Simon-Louis; and Willows, *Salix* spp.

Eggs of the satin moth are laid in masses on trunks, branches and leaves of the host or other trees or objects nearby. In 1958, in Vernon the moths began egg laying by about June 10. The larvae hatch in about two weeks and begin to skeletonize the leaves. After a few weeks they spin minute silken "huts" in bark crevices where they spend the winter. In Vernon, in 1958, these "huts" began to appear in late July. In the spring, shortly after the leaves have unfolded, the larvae resume feeding and may denude the trees by mid-June.

The best times to spray are about two weeks after the first larvae emerge from their winter quarters or at the peak of egg hatch. At these times the population consists mainly of early instar larvae which are most easily killed.

In 1958, poplar groves and some willow shade trees in and near Vernon, Kelowna, and Penticton were severely damaged by the satin moth. In some cases the trees were completely defoliated. These three cities were forced to apply control methods. A few resort and home owners in the Okanagan, notably at Mission Flats, south of Kelowna, and Woods Lake between Vernon and Kelowna, and at Okanagan Landing were also forced to spray their shade trees.

The city of Vernon hired a machine with a "Bean" pump, which was capable of applying 20 gallons of liquid per minute. A turbo mist fan attachment was used to narrow the spray stream and assure coverage of the 60 foot trees in Polson Park. DDT at 6 lbs. 50% wettable powder per 100 gallons of water applied on July 7 gave excellent control of the newly hatched larvae.

The cities of Penticton and Kelowna obtained similar results at the recommended dosage of 2-3 lbs. of 50% DDT wettable powder in 100 gallons of water.

References

Condrashoff S. F. 1957. Advance of the Satin Moth, **Stilpnotia salicis** (L.) Into the interior of British Columbia.

Proc. of the Ent. Soc. of B.C. Vol. 53, Feb. 15, pp. 26-27.

SEVIN AS AN ORCHARD INSECTICIDE IN BRITISH COLUMBIA[1]

R. S. DOWNING[2]

The insecticide Sevin, unlike most of our present day insecticides, is an aryl urethane chemically termed N-methyl-1-naphthyl carbamate[3]. This compound has special interest where insects have become resistant to our commonly used insecticides such as DDT and malathion. Sevin has the very desirable characteristics of a comparatively low mammalian toxicity; the oral LD50 to rats of 500-700 mg/kg (1) is lower than that of DDT. Because of these factors, and since reports of preliminary experiments with Sevin for insect control from other institutions were favourable, experimental work with Sevin as an orchard insecticide was started at Summerland in 1957.

GENERAL METHODS

Sevin was compared with either DDT or malathion depending upon the insect involved. Sevin and DDT were used as 50 per cent wettable powders and malathion as a 25 per cent wettable powder.

The method of application of the insecticide depended on the type and size of orchard available for experimentation. Where a large orchard with large trees was available, an automatic concentrate air-blast sprayer was used, whereas if the orchard was small, or if the trees were small, a high-volume, hand-gun sprayer was used. Except for one instance in which a Trump AS 36[4] concentrate sprayer was used, all concentrate spraying was done with a Turbo-Mist[5] concentrate sprayer. These sprayers applied about 50 gallons of spray liquid per acre. Unless otherwise stated, all hand-gun spraying was done with a two-gun, high-pressure sprayer, and the spray material was applied until it started to drip from the tree foliage.

RESULTS AND DISCUSSION

Control of the Codling Moth

In 1957, Sevin and DDT were applied with a concentrate sprayer to McIntosh and Golden Delicious in one orchard, and Delicious apples in another orchard to control severe infestations of the codling moth, *Carpocapsa pomonella* (L.). Three first brood sprays and one second brood spray were applied in each orchard. The numbers of apples injured by the codling moth were recorded at harvest.

In 1958, Sevin and DDT were applied with a concentrate sprayer to a Northern Spy apple orchard to control an infestation of the codling moth that had practically destroyed the previous year's crop. Starting one week after petal fall, three first brood applications, and two second brood applications, were made.

Sevin at six pounds per acre gave better control of the codling moth (Tables 1, 2) than did DDT at the same dosage.

Observations on the abundance of the apple aphid, *Aphis pomi* DeG., indicated that Sevin, as used against the codling moth, also controlled the aphid; but DDT allowed the aphid to develop heavy infestations. This was confirmed by Pielou (2) who studied the compound strictly as an aphicide.

Some mites, on the other hand, were not suppressed by applications of Sevin and in this respect Sevin was similar to DDT. Both years that Sevin was used for codling moth control, mites increased in the orchards. In 1958, the two-spotted spider mite, *Tetranychus bimaculatus* Harvey, de-

[1] Contribution No. 9, from the Regional Research Station, Canada Department of Agriculture, Summerland, British Columbia.
[2] Associate Entomologist.
[3] Union Carbide Chemicals Company, White Plains, New York.
[4] Trump Limited, Oliver, B.C.
[5] Okanagan Turbo Sprayers Limited, Penticton, B.C.

veloped to such high infestations that a special miticide, 18.5 per cent Kelthane wettable powder, 10 pounds per acre, had to be applied to all plots.

Control of the Eye-Spotted Bud Moth

The recommended method of controlling the eye-spotted bud moth, *Spilonota ocellana* (D. & S.) in the Okanagan Valley is to apply malathion in pre-bloom or summer sprays.

In 1957, Sevin was compared with DDT and malathion against the bud moth. The materials were applied at the pink bud stage with a stirrup pump sprayer to young Delicious apple trees. One week after treatment the bud moth nests on each of three, single-tree replicates were examined and the average percentage mortali-

TABLE 1—Percentage Apples Injured by the Codling Moth at Harvest After Four Summer Applications of Sevin and DDT to Three Varieties of Apple Trees by Concentrate Sprayer. Naramata, B.C., 1957.

Insecticide, 50% w.p.	Pounds per acre[1]	No. of apples examined	Wormy apples, %
Golden Delicious			
Sevin	6	3000	6.4
DDT	6	2535	12.5
McIntosh			
Sevin	6	1560	1.4
DDT	6	1536	8.4
Red Delicious			
Sevin	6	2060	2.0
DDT	6	2000	6.6

[1] Application made on May 23-24, June 3-6, June 17-20 and August 5-9.

TABLE 2—Percentage Apples Injured by the Codling Moth at Harvest After Five Summer Applications of Sevin and DDT to Spy Apple Trees by Concentrate Sprayer. Summerland, B.C., 1958.

Insecticide, 50% w.p.	Pounds per acre[1]	No. of apples examined	Wormy apples, %
Sevin	6	2518	0.0
DDT	6	2550	1.7

[1] Applications made on May 20, June 2, June 16-17, July 17, and August 7.

TABLE 3—Average Numbers of Eye-Spotted Bud Moth Nests Found in a Ten Minute Search Per Tree After Sevin and Malathion were Applied to Jonathan Apple at Pink Bud Stage by Concentrate Sprayer. Summerland, B.C., 1958.

Insecticide	Pounds per acre	Numbers of bud moth nests Rep. 1	Rep. 2	Ave.
Sevin, 50% w.p.	8	6	11	8
Malathion, 25% w.p.	16	8	21	14
Check—no treatment	—	65	92	79

ties of bud moth larvae were:

Insecticide	Pounds per 100 gallons	Mortality, %
Sevin, 50 per cent	1.5	100
Malathion, 25 per cent	2.0	100
DDT, 50 per cent	1.5	1.7
Check—no treatment	—	0

In 1958, Sevin and malathion were applied at the pink bud stage to replicated, one-half acre plots of Jonathan apple trees with a Turbo-Mist sprayer. One month after spraying, each of six trees per plot was examined for ten minutes and the number of infested bud moth nests recorded (Table 3). This showed that Sevin was just as effective as malathion in controlling the overwintered eye-spotted bud moth at the pink bud stage of apple.

Furthermore, when it was compared with DDT in summer sprays to control the codling moth, as in the experiments already discussed, Sevin prevented injury from the newly hatched bud moth larvae in late July and August. In the DDT-sprayed fruit, on the other hand, bud moth injury was common.

Control of the Fruit Tree Leaf Roller

Recommended control for the fruit tree leaf roller, *Archips argyrospila* (Wlk.) is by application of DDT at the pink bud stage of apple (3); at this stage about 15 per cent of the overwintered eggs of this species have hatched. However, reports from growers, and general observations by the writer in the past few years, indicate that DDT has proven only fairly successful.

Sevin, 1.5 pounds per 100 gallons, was compared with DDT, 1.5 pounds, for leaf roller control in 1957. A hand-gun sprayer was used to apply the insecticides at the pink bud stage to heavily infested Delicious apple trees. Three weeks after spraying, each of three trees per plot was examined for ten minutes, and the number of leaf roller nests found in that time was noted. The average numbers of nests per tree per plot were: Sevin, 1; DDT, 16; Check, 95.

In 1958, Sevin, 8 pounds per acre, and DDT, 12 pounds, were applied with a Turbo-Mist concentrate sprayer to very large Newtown apple trees in the early pink bud stage when the overwintered leaf roller eggs were starting to hatch. Records of leaf roller infestation were taken three weeks later and in the same manner as the previous experiment, but six trees per plot were examined instead of three. The average numbers of nests per tree per plot were: Sevin, 4; DDT, 17; Check, 108.

These experiments show that Sevin was more effective against the larvae of the fruit tree leaf roller than DDT when applied at the pink bud stage of apple.

When these materials were applied earlier, they were less effective. This was evident in 1958 when they were applied by hand-gun sprayer at the pink bud stage of apricot, i.e., approximately two weeks earlier than that stage on apple. One month after the application of Sevin, 1.5 pounds per 100 gallons, and DDT, 1.5 pounds, records of leaf roller infestation were taken by examining five trees per plot, and recording the numbers of leaf roller nests. By plots the average numbers of nests per tree were: Sevin, 53; DDT, 52; Check, 143. It is assumed, in this case, that after having weathered for two weeks or more, the deposits had deteriorated until they were incapable of killing the larvae as they hatched from the overwintered eggs.

Control of the Peach Twig Borer

The usual method of controlling the peach twig borer, *Anarsia lineatella* Zell., has been to apply DDT at the pink or petal-fall stage of peach, or apricot (4), with the intent of killing the larva before it can cause injury to the twigs.

Sevin, 1.5 pounds per 100 gallons, was compared to DDT, 1.5 pounds, in 1958 when both materials were applied with a hand-gun sprayer to apricots that were in the pink bud stage. One month later, the numbers of flagged twigs were counted on each of five trees per plot. The average numbers of flagged twigs per tree in each plot were: Sevin, 0.0; DDT, 0.7; Check, 28.7.

Control of Lecanium Scales

Soft scales, particularly *Lecanium* spp., have been particularly troublesome during the last few years, especially in 1957, in many peach and apricot orchards in the Okanagan Valley. Proverbs (5) experimented with scale insects that he designated as *Lecanium* sp. A and *Lecanium* sp. D. These have since been identified by Mr. J. H. H. Phillips, Vineland Station, Ontario as *Lecanium coryli* L. and *L. caryae Fitch*, respectively. Another species, *L. cerasifex* Fitch, has also become troublesome since Proverbs reported on his work. He stated (5) that malathion, as a summer spray, gave excellent control of nymphs of *Lecanium* sp. A, but a late pink bud spray was not so effective.

Because the fruit grower is usually very busy when summer spraying is most effective against *Lecanium* scales, pink bud, or pre-bloom sprays are considered preferable. With that in mind, Sevin was compared with malathion in concentrate application to peach or apricot trees at the pink bud stage. Large plots, one-half acre in size, were used to minimize reinfestation from one plot to another. In most cases, results were not recorded until the scale insect had matured, its eggs had hatched, and the young nymphs had moved from the twigs to the leaves. The results of these pink-bud spray experiments, conducted in 1957 and 1958 against *L. cerasifex*, are summarized in Table 4.

TABLE 4—Average Numbers of the Scale Lecanium cerasifex Fitch per 50 Leaves in August After Application of Sevin and Malathion to Peach Trees, in 1957, and to Apricot Trees, in 1958, in the Pink Bud Stage by Concentrate Sprayer. Summerland, B.C.

Insecticide	Pounds per acre	Average numbers of scales per 50 leaves On peach trees 1957[1]	On apricot trees 1958[2]
Sevin, 50% w.p.	8	64	77
Malathion, 25% w.p.	16	349	539
Check—no treatment	—	1580	958

[1] Average of two replicates.
[2] Average of four replicates.

In another apricot orchard, pink bud sprays of Sevin, 8 pounds per acre, and malathion, 16 pounds, applied with a concentrate sprayer, were compared for the control of *L. coryli*. One month after the applications, two twigs were sampled from each of five trees per treatment and the number of live and dead scales were counted. The percentage mortalities were: Sevin, 96.6%; malathion 94.4%; Check, 3.9%.

It is fairly evident from these experiments that Sevin was effective against the two species of *Lecanium*, being better than malathion against *L. cerasifex* and as good against *L. coryli*.

Chemical Control of the Pear Psylla

The pear psylla, *Psylla pyricola* Foerst., was a serious pest in 1958. Infestations were numerous early in the season, and many fruit growers had difficulty controlling the pest with the recommended spray chemicals, especially malathion.

Sevin, 12 pounds per acre, was compared with malathion, 12 pounds, as a spray concentrate for pear psylla control during the summer of 1958. In one orchard, 10 days after treatment, the average numbers of live psyllids counted on samples of 20 leaves taken from each of five trees per plot were: Sevin, 1.0; malathion, 18.6; Check, 41.3. In two other or-

chards where Sevin was used, similar results were obtained indicating that it is a promising chemical for the control of the pear psylla.

SUMMARY

Good control of eight species of insects was obtained from 50 per cent Sevin wettable powder [N-methyl-1-naphthyl carbamate] applied as follows:

1. Pink bud application on apple; 8 lb. per acre or, 1.5 lb. per 100 gal.
   Eye-spotted bud moth, *Spilonota ocellana* (D. & S.).
   Fruit tree leaf roller, *Archips argyrospila* (Wlk.).
2. Pink bud application on peach and apricot; 8 lb. per acre.
   Lecanium coryli L.
   Lecanium cerasifex Fitch.
3. Pink bud application on apricot; 1.5 lb. per 100 gal.
   Peach twig borer, *Anarsia lineatella* Zell.
4. Three or more summer applications on apple; 6 lb. per acre.
   Codling moth, *Carpocapsa pomonella* (L.).
   Apple aphid, *Aphis pomi* DeG.
5. Summer application on pear; 12 lb. per acre.
   Pear psylla, *Psylla pyricola* Foerst.

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REFERENCES

1. Anonymous. Experimental insecticide Sevin. Agricultural Chemicals Division, Union Carbide Chemicals Company, New York, N.Y. Feb. 15, 1957.
2. Pielou, D. P., and K. Williams. The effectiveness of insecticide residues in preventing reinfestation by the apple aphid *Aphis pomi* DeG. In preparation.
3. Anonymous. Control of tree-fruit pests and diseases. British Columbia Dept. Agr. poster. 1958.
4. Proverbs, M.D. Chemical control of the peach twig borer, *Anarsia lineatella* Zell. (Lepidoptera: Gelechiidae), in the Okanagan Valley of British Columbia. Proc. Entomol. Soc. British Columbia 51: 31-36. 1954.
5. Proverbs, M.D. Control of soft scales (Homoptera: Coccidae) in British Columbia peach and apricot orchards. Proc. Entomol. Soc. British Columbia 54: 3-8. 1957.

Two Unusual Breeding Places of Ptinus tectus Boield. Ocellus Brown, the Brown Spider Beetle

A pest control operator consulted me about a house which he had twice fumigated with cyanide for so-called "wood borers" which were still coming out of the walls. I inspected the place and found spider beetles, on stairs on the upper floor, on the hall floor and issuing from the inner wall of the hall. Enquiry revealed that the owners had finished the top floor and the stairs with wall board about 5/8-inch thick that was apparently of corn stalk pulp bonded with casein, and had then papered over it. The emergence holes were distributed over the slabs of wallboard. Examination of the basement revealed a few beetles that had apparently emerged from the inner side of the wall board and had dropped or crawled down the inside of the wall. I came to the conclusion that beetles had oviposited on the boards in the factory, having been attracted by the casein bonding glue and that the grubs had fed and developed in the material and were now emerging as adults. The fumigation was not of sufficient strength to penetrate the wallpaper and kill the insects in their pupal cases inside the boards. Fumigation with methyl bromide corrected the trouble.

The second unusual breeding place occurred in a country cottage south of Langley. The owners wrote me about "wood-boring insects" issuing from papered walls around a plate glass window and from the hall. The walls showed emergence holes as plentiful as if the place had been hit by a blast from a shotgun. Opening the wall revealed laths covered with thick building paper, which had been stuck to the laths with a heavy coating of animal glue. Apparently spider beetles entered the wall and laid eggs on the glued paper; the grubs fed between the lath and the paper and formed pupal cells just below the wallpaper, through which they emerged leaving the shot-hole appearance, exactly like the emergence holes of Anobiid beetles.

—*G. J. Spencer, University of British Columbia, Vancouver.*

A BRIEF HISTORY OF THE POPLAR AND WILLOW BORER, *Sternochetus lapathi* (L.), IN BRITISH COLUMBIA[1]

By C. B. COTTRELL

The poplar and willow borer, *Sternochetus lapathi* (L.), introduced from Europe, was first observed in North America in 1882, when a single specimen was collected in New York (Herrick, 1935). During the next 20 years the weevil was observed in many localities in the northeastern United States (Matheson, 1917). In 1906, the first Canadian records were taken at three localities in Ontario (Cosens, 1912), and in 1908, Carolina poplars were attacked at Dundurn, Saskatchewan (Fletcher and Gibson, 1908). Between 1909 and 1916, occurrences were reported from many widely separated points in Ontario, and at Montreal, Quebec (Caesar, 1916).

The first known record of the poplar and willow borer in the Pacific Northwest was at Vernon, where in 1923, the late Col. A. E. Parlow collected a specimen. In 1924, poplar and willow trees in the Tourist Park at Kelowna were found to be infested, followed by reports of infestations at Penticton in 1932 and Summerland in 1934. The weevil's widespread distribution in the Okanagan Valley suggests that it was probably well established before these dates.

Other early records in the west were: Priest River, Idaho (P. C. Johnston, in litt.) and Tacoma, Washington, 1931 (M. H. Hatch, in litt.) and near Portland, Oregon in 1933 (Furniss, 1939).

A report of the borer's occurrence at Riske Creek in the Chilcotin area appears in the 1931 edition of the Canadian Insect Pest Review. For several reasons this record seems questionable: no specimen was taken; the host, trembling aspen (E. R. Buckell, in litt.), is unusual; and no weevil activity has been recorded in this area before or since.

[1] Contribution No. 555, Forest Biology Division, Research Branch, Department of Agriculture, Ottawa, Canada.

[2] Forest Biology Laboratory, Vernon, B.C.

On the Lower Mainland of British Columbia the first damage report came from a Vancouver garden in 1930, although it was stated in the Annual Report of the Forest Insect Laboratory at Vernon (W. G. Mathers, 1930), that the insect's presence had been known in this area for at least three years. In 1933 willows were attacked in Stanley Park, in 1934 at Green Timbers, and on Sumas Prairie in 1936.

Few infestations were recorded from 1936 to 1946, but in the period 1947 to 1949, with the expansion of the Forest Insect Survey staff, many new locality records were established: Chilliwack, Yale and Pitt Lake, 1947; Seymour Creek and Hope, 1948; Surrey, Allouette Lake, and Chehalis River, 1949. This indicates that the weevil was distributed throughout the Fraser Valley prior to 1947. On Vancouver Island, four records were obtained in 1948: Nanaimo, Coleman Creek, Port Alberni and Cowichan Lake.

Dr. M. Hatch of the University of Washington apparently has the first Kootenay record — a specimen collected at Creston in 1941; otherwise very little is known about the weevil's activities there before 1949. That year, numerous specimens were collected around the west arm of Kootenay Lake in the following localities: Queens Bay, Balfour, Kokanee, Nelson and Harrop. In 1951 several collections were made between Castlegar and Trail, and on the east side of Kootenay Lake at Crawford Bay. In 1952, damage was noted around the north end of Kootenay Lake and at Grand Forks in the Kettle Valley. In 1953, attacks were observed at Nakusp and Arrowhead, and at Kimberley and Bull River in the East Kootenay. Weevil attacks have continued in most of the above-mentioned infestations and in each successive year new locality records were obtained: Slocan

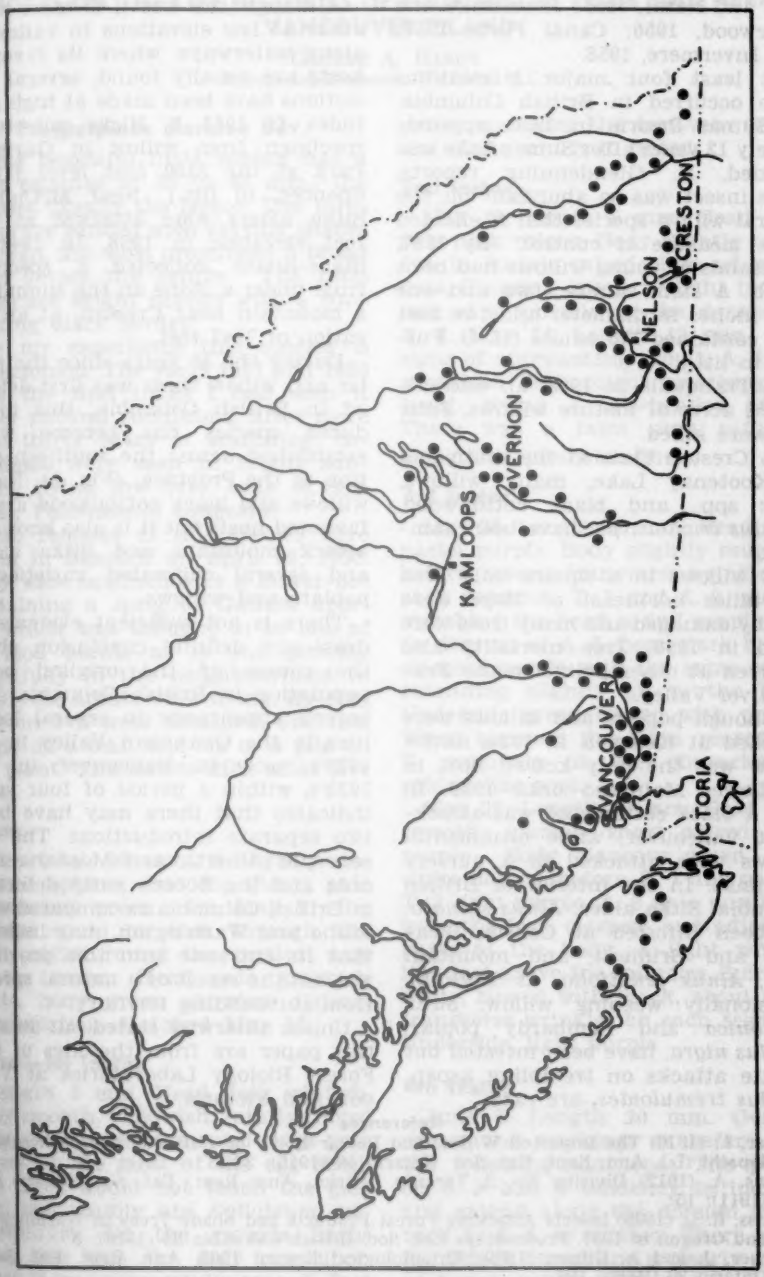

Fig 1.—Distribution of Sternechetus lapathi in British Columbia.

City and Natal, 1955; Revelstoke and Edgewood, 1956; Canal Flats, 1957; and Invermere, 1958.

At least four major infestations have occurred in British Columbia. At Sumas Prairie in 1936, approximately 12 years after Sumas Lake was drained, R. Glendenning reports, "this insect was so abundant on the several willow species that it effected some measure of control." By 1937, thousands of young willows had been killed. A stem sample, two and one half inches in diameter and two feet long contained 175 adults (H. G. Fulton, in litt.).

At Tranquille in 1958, an estimated 250 acres of mature willows, *Salix* sp., were killed.

On Creston Flats at the south end of Kootenay Lake, many willows, *Salix* spp., and black cottonwood, *Populus trichocarpa*, have been damaged.

All willows in a square mile area two miles northeast of Hope were heavily damaged and many trees were killed in 1958. Tree mortality also occurred at other points in the Fraser River Valley.

Although poplars and willows were attacked at Kelowna in 1924, native willow was the only known host in the Lower Mainland until 1939. In 1939, a black cottonwood was attacked at Vancouver, while ornamental willows were attacked in a nursery at Sumas. In the interior of British Columbia, Sitka alder, *Alnus sinuata*, has been infested at Celista, Sicamous and Brilliant, and mountain alder, *Alnus tenuifolia*, at Taghum. Occasionally weeping willow, *Salix babylonica* and Lombardy poplar, *Populus nigra*, have been infested but to date attacks on trembling aspen, *Populus tremuloides*, are rare.

Although the weevil is most numerous at low elevations in valleys or along waterways, where its favoured hosts are usually found, several collections have been made at high altitudes. In 1953, S. Hicks collected a specimen from willow in Garibaldi Park at the 3100 foot level (G. J. Spencer, in litt.). Near McCulloch, Sitka alders were attacked at 4100 feet elevation in 1958. In 1946, G. Stace-Smith collected a specimen from under a stone on the summit of a mountain near Creston, at an elevation of 7147 feet.

During the 36 years since the poplar and willow borer was first detected in British Columbia, this introduced species has become well established across the southern portion of the Province. (Fig. 1). Native willows and black cottonwood are its favoured hosts but it is also known to attack mountain and Sitka alders and several cultivated varieties of poplars and willows.

There is not sufficient evidence to draw any definite conclusion about the source of the original borer population in British Columbia. The borer's appearance in several localities in the Okanagan Valley in the 1920's, and in Vancouver in the 1930's, within a period of four years indicates that there may have been two separate introductions. The absence of Alberta and Montana records and the borer's early detection in British Columbia as compared with Idaho and Washington, may indicate that its entrance into this province was not the result of a natural spread from surrounding territory.

Unless otherwise stated, all data in this paper are from the files of the Forest Biology Laboratories at Vernon and Victoria.

References

Caesar, L. (1916) The Imported Willow and Poplar Borer or Curculio, **Cryptorhynchus lapathi** (L.). Ann. Rept. Ent. Soc. Ontario 46 (1915): 33-43.

Cosens, A. (1912) Division No. 3, Toronto District, Ann. Rept. Ent. Soc. Ontario 42 (1911): 15.

Furniss, R. L. (1939) Insects Attacking Forest Products and Shade Trees in Washington and Oregon in 1937. Proceedings Ent. Soc. British Columbia 35 (1939): 5.

Fletcher, J. and A. Gibson (1909) Entomological Record 1908, Ann. Rept. Ent. Soc. Ontario 39 (1908): 109.

Herrick, G. W. (1935) Insect Enemies of Shade-Trees, Comstock Co., Ithaca, N.Y.

Matheson, R. (1917) The Poplar and Willow Borer. Cornell University, Agricultural Experiment Station, Bulletin 388. 458.

NOTES ON THE LIFE HISTORIES OF FOUR MOTHS FROM SOUTHERN VANCOUVER ISLAND

GEORGE A. HARDY
Provincial Museum, Victoria, B.C.

Prosperpinus clarkiae Bdv.

This beautiful little sphinx has a wing expanse of 35 to 40 mm., the females usually the larger. The forewings are banded with varying shades of green, the most prominent a broad band across the centre. The hind wings are bright orange with a contrasting black border.

In my experience this species is not common. The years 1957 and 1958 were the first times I had seen it under natural conditions, after more than thirty years of searching. Individuals were seen in bright sunshine, flying low over beds of sea-blush, *Valerianella congesta*.

Two females of this species were taken in Saanich on April 29, 1958. They were confined over a flower-pot containing a sprig of *Galium aparine* which was thought to be one of its food plants as it was growing plentifully in the neighbourhood in which the adults were flying. By May 4 seven ova were obtained, one laid singly on a leaf, and six in a pile on the plant. The adults died after five days.

Ovum

Size 1 by .90 mm., a slightly depressed sphere, smooth, shiny, pale translucent green. On May 11 the embryo could be seen through the shell, curled round the vertical axis of the ovum. Head pale greenish white, body green showing distinct segmentation. Hatched May 12.

Larva—1st Instar

Length 3 mm. Head dull, whitish. Body smooth, yellowish, faintly tinged with green, intersegmental rings pale yellow. It ate most of the egg shell. The larva would not touch the galium, but readily ate *Epilobium angustifolium*. Of the various herbs tried, this was the only one upon which it was successfully reared. Just prior to the first moult the larva was 5 mm. long, the body a dull glaucous-green, matching the mid-vein of the leaf along which it rested.

2nd Instar

May 21, length 6 mm. Head dull, pale flesh colour. Body slightly rough due to minute raised close-set white dots. Glaucous green, a slight indication of a tubercle on the dorsum of A. 8. May 24. Length 12 mm. with signs of approaching moult. A. 9 was a pinkish flesh colour matching the head, giving a two-headed effect. There was a faint pink suffusion along the spiracular line.

3rd Instar

May 26. Length 15 mm. Head light pastel purple. Body slightly rough as before, several transverse wrinkles on each segment. T. 1 and A. 9, purple, matching the head, a dull purple spot on dorsum of A. 8. Legs, dark brown, claspers purple with the same colour extending slightly on to the body. Underside green tinged with purple. When alarmed the larva reared the T. segments in the characteristic sphinx-like pose.

May 29. Length 20 mm. Head dull, smooth, sparsely short haired, pale purple. Body glaucous green, with white dots as before. T. 1 and part of T. 2 light purple. A. 9 pale purple, as were the legs, claspers and adjoining parts of the body. A light whitish line just above the spiracles. Spiracles white, ringed with black, about eight transverse wrinkles on each segment. Underside, light purple.

4th Instar

June 1. Length 20 mm. General colour and markings as before with the following additions: The purple on A. 9 had a tendency to increase and extend along the dorsum as far back as A. 6, or further. There was a faint dark dorsal and a clearly marked lemon yellow subdorsal line, with a distinct purple boss on the dorsum of A. 8. where the horn occurs in most

Sphingid larvae. The body tapered slightly towards the head.

5th Instar

June 9. Length 30 mm. Head purplish brown, covered with sparse, short hairs. Body with a wide dorsal band, black or dark fuscous having a tinge of purple. A. 1. to 5. with a pair of small, creamy dots. A. 8. with a round pink boss on dorsum, sides yellowish with ten thick, elongate, slightly oblique black bars, containing the spiracles in the centre of the row of bars. The whole body dotted minutely with black, and the underside a light purple colour. By June 13 the length was 45 mm. Head dull purplish-brown. Body fuscous above as before. A. 8. with a black-rimmed pink boss centred with an elliptical black spot. Sides yellow with a broad wavy black band running along and including the line of spiracles. Back and sides thickly dotted with black, the dots closely grouped at the juncture of the segments. Legs and claspers flesh colour. The underside purple. June 19. Length 55 mm. Full grown. By June 24 it had descended to the soil for pupation.

Pupa

Size 25 mm. by 7 mm. Smooth, dull, wing cases etched with a feathered pattern of fine lines. A. segments coarsely punctate on the anterior border, light brown, spiracles black. Cremaster a stout bifid spine terminating a narrow rugose protuberance on the last segment. Length of base and spine 2 mm. The pupa was widest at the middle of the A. segments, with the wing cases proportionally short and narrow.

Lacinipolia petalis fletcheri Grt.

This is a rather common moth during June and July when it comes to light. The wing expanse averages 30 mm. and the general colour is light grey superimposed with darker lines and markings. A characteristic feature is the juncture of the orbicular and reniform spots at their lower edges, which readily separates this species from the very similar *L. pensilis* Grt. in which these spots are separate.

The following notes cover two years. Difficulties arose during the winter with the first group, so that the sequence is a blending of two groups, each supplying deficiencies in the other.

One batch of ova consisted of 95 eggs laid on or about June 24, 1955, placed indiscriminately on the sides and bottom of the container. The other was a similar number laid on July 7, 1957.

Ovum

Size, 1 mm. by .90 mm. Conical, finely ribbed, white; the apex and a ring slightly below, brown.

Larva—1st Instar

July 9. Length 2mm. Head light brown. Body pale translucent brown, with small tubercles bearing setae. The egg-shell was not eaten. After trying various plants the caterpillar accepted *Alnus rubra*.

2nd Instar

July 18. Length 4 mm. Head honey-coloured, short haired. Body olive-brown, smooth with scattered short setae. It ate small round holes in the epidermis on the underside of the leaf.

3rd Instar

July 28. Length 7 mm. Head as before. Body olive-brown, a thin white dorsal line with faint white suffused patches on each side of it on the centre of the A. segments. Tubercles black, each with a short seta. The larva kept out of sight by day under the dead leaves that lay at the bottom of the pile accumulated as fresh ones were added. It was very sluggish, hardly moving if touched.

4th Instar

August 7. Length 10 mm. Head as before. Body a drab fuscous brown, dorsum with grey lozenge-shaped saddles on the centre of each A. segment. Spiracular line broad, pale honey colour. Spiracles black. Underside pale fuscous. finely flecked with grey dots and etchings.

5th Instar

August 13. Length 17 mm. Much as before but darker, two white tubercles on the dorsum of A. 8.

6th Instar

August 29. Length 20 mm. Head pale brown, a dark V on front, sides freckled with fuscous. Body pale yellow-brown, heavily flecked with fuscous. Markings as before. By September 9 the body colour varied in individuals from dark fuscous to light grey-green, and the markings were not so evident. Some of the dark forms had two light ticks on the anterior margin of each segment. The lighter ones had a Y mark in the centre of A. segments. On October 19 they were very sluggish; evidently the winter diapause was imminent. The larvae were placed in a 10-inch flower-pot with moss and alder leaves. During the following winter they nibbled at slices of carrot.

February 9, 1958. Length 25 mm. The larvae came through the winter in good condition. No moult was observed after hibernation. Head shiny, smooth, dark brown mottled with lighter brown, sparsely short haired. Body fuscous-brown tinged with pink, having a thin broken white black-edged dorsal line with a suffused fuscous spot on the intersegmental region. T. segments darker. A dark spot on each side of A. 8. Spiracular broad, indistinct and broken, pale luteus. Underside similar to the upper but lighter in colour. The whole body covered with minute grey dots. Claspers flesh coloured with a dark spot on the outer side. A. 9. fuscous. The body tapered slightly towards the head. Just before pupation on March 29 the larva was 25 mm. in length. T. segments and A. O. darker than the rest. Dorsum showed two faint, dark dashes on the centre of the segments.

Pupa

Size 15 mm. by 4 mm. Smooth with a dull gloss, light reddish brown. Spiracles black. Cremaster consisting of about six stiff, straight hairs bunched together on a smooth knob at the end of the last segment.

Imago

Emerged May 17 to 21.

Xylomiges cognata Sm.

This is a regular visitor to my porch light during March. The wing expanse is 35 mm. The forewings have a light grey background, on which are fine black lines and etchings, leaving a noticeably oblique lighter area across the centre. The hind wings are whitish with a conspicuous black dot in the centre and a thin black border on the hind margin.

A female taken at light in Saanich, on February 8, 1958, had laid 65 ova by February 13. The eggs were deposited on the side of the container in a single batch of one layer.

Ovum

Size 1 mm. by .50 mm. A flattened sphere, smooth, shiny with about 45 faint vertical ribs. Micropylar area depressed, reticulate. Pale cream colour, turning through light pink, pinkish-brown, to lead colour at hatching time. Hatched March 18, 1958

Larva—1st Instar

Length 2 mm. Head large in proportion, shiny, jet black. Body with a black cervical plate on T. 1. Rest of body a sordid bluish-white, short haired. They did not eat the egg-shell. They were very restless, wandering ceaselessly with a pronounced tendency to climb upwards and showing no desire to eat for several days. Finally they nibbled at the buds of *Salix mackenziana* into which they burrowed out of sight.

2nd Instar

March 29. Length 6 mm. Head and cervical plate shiny, yet black. Body blue-black, semi-translucent. Dorsal and subdorsals thin, faint, milky-white; tubercles noticeably black. Legs black, claspers concolorous with the underside and upper part of the body.

3rd Instar

April 1. Length 12 mm. Head shiny, jet black. Body fuscous green, dorsal and subdorsals milky-white. Spiracular line consisting of two whitish lines

enclosing pale green mottled with fuscous; spiracles black, underside light dusky green including the claspers, legs dark brown; black tubercles on the dorsum and sides very evident. As the *Salix* buds expanded the larvae tied the leaves together with silk, remaining out of sight within the leafy tent.

4th Instar

April 5. Length 15 mm. Head black with lighter mottling on sides. Body with a broad light fuscous green band including the white dorsal, bordered by the white subdorsals. Between the sub-dorsals and the spiracular line the ground colour is a darker shade of the dorsum. Spiracular line broad, white, flecked along the centre with pale green, which included the black spiracles.

April 9. Length 25 mm. They rested concealed in a folded leaf.

5th Instar

April 14. Length 30 mm. Head dark brown, with light mottlings on vertex and sides. Body with cervical plate shiny, dark brown mottled with lighter brown; rest of body grey-green between the white dorsal and sub-dorsals, darker below the latter, spiracular line a sordid grey, dorsum of A. segments with a dark U shaped line becoming more marked toward the last segment. Whole surface of body dotted with minute white spots.

April 20. Full grown. Length, 40 mm. Head pale flesh-brown, two oblique dark brown bars on front, vertex and sides faintly reticulated with dark brown. Body with shiny cervical plate concolorous with body, three white bars an extensions of dorsal and sub-dorsal lines which were white edged with fuscous; spiracular line less evident than before though broad and nearly concolorous with the sordid flesh of the underside, centred by a pale green suffusion, edged above with black, below with white. Spiracles black, legs pale brown, claspers the same colour as the underside. A. 4-9 with narrow fuscous U marks as before, the open end of the U directed forward. About April 30 the larvae spun light silken cells among the debris, where they lay quiescent until May 6 before the final change to the pupa was effected.

Pupa

Size 17 mm. by 5 mm. Smooth, shiny, wing cases minutely etched with wrinkles. A. segments finely punctate on the anterior margin, dark mahogany brown. Cremaster with 2 parallel hairs slightly recurved at the tips.

Semiothisa teucaria Stkr.

This fairly common geometer has a wing expanse of 30 mm. Both fore and hind wings are light grey heavily dusted with fuscous. The forewings have three dark lines crossing them while the hindwings have but two.

It is closely associated with Garry oaks, and may be disturbed by day among the grass and herbage beneath the trees. It flies up quickly and alights as suddenly in the grass after a short flight, a manoeuvre that is repeated as often as it is disturbed. At Saanich 8 ova were obtained from a captive female on July 24, 1957. The eggs were laid singly on an oak leaf and on the sides of the container.

Ovum

Size .90 mm. by .50 mm. Oval, minutely reticulate, green turning dark at maturity. Hatched August 3, 1957.

Larva—1st Instar

Length 3 mm. Head shiny, pale brown. Body pale brownish green to nearly colourless, translucent, with 6 very fine lines on dorum and sides, more pronounced on T. segments, underside darker. Fed upon Garry oak, *Quercus garryana*.

2nd Instar

August 11. Length 5 mm. Head and body as before, less translucent.

3rd Instar

August 17. Length 7 mm. Head pale whitish green, dull, with a few short setae. Four vertical bars of light brown feathering. Body smooth, with a rather prominent spiracular fold, grey-green, with 6 more faint light

lines on dorsum and a broader whitish spiracular line. Underside striped with alternate light and fuscous lines.

4th Instar

August 23. Length 16 mm. General colour and markings as before. Some individuals dark fuscous green with a broken whitish spiracular line, dark intersegmental rings and a pair of black spots on sides of A. 1 and A. 2.

5th Instar

August 31. Length 23 mm. Head milky green, mottled and feathered with light brown. Body grey-green with a tinge of cinnamon on ring joints, dorsum and sides with closely spaced pale brown lines, underside with black dots on segments. Some had a black mark on the centre of sides, in others the black was replaced with yellow. The cinnamon tinge varied among the larvae. The overall effect was to simulate the oak twigs, even to a thin short pubescence. They were full grown by September 4. Head pale biege with brown feathering as before. Body yellowish-brown with many fine lines and pale yellow dashes on sides of segments. September 12. All larvae pupated among the dead leaves at the bottom of jar.

Pupa

Size 11 mm. by 3 mm. Slender, smooth, slightly shiny, finely wrinkled on wing cases, punctate on A. segments, dark piceous brown. Cremaster a bifid spine with straight tips.

On Mounting Lice by the Ris Lambers Method for Aphids

In the spring of 1958 Mr. Ron Forbes of the Federal Crop Insect Laboratory on the Campus showed me some microscope slides of aphids—the finest and clearest preparations of their kind that I had ever seen. He stated that they were made by the Hille Ris Lambers method and I immediately wondered if Mallophaga and Anoplura could be enslided by the same technique.

Through the efforts of Miss Eleanor Higham, student technician, I now have about 1000 slides of these 2 Orders made by this method. For practical purposes it is nearly as good as the standard KOH-Canada balsam method with the advantage that it is very much faster; one can have finished slides in about 45 minutes.

The method is as follows:

Place the insects in 90 per cent alcohol in a just-boiling water-bath until soft and soggy-looking i.e. in from 2-5 minutes. Then remove them and place in 10 per cent KOH in hot water-bath for from 1 to 5 minutes; experience tells how long. Transfer to Chloralphenol solution in the hot bath for 2 to 3 minutes to clear and mount in Hille Ris Lambers medium.

The formula for the mounting medium is:

Gum arabic, clean white powdered	12 grams
Concentrated pure glycerine	6½ cc
Chloralhydrate	20 grams
Distilled water	40 cc

Dissolve the gum arabic with the other reagents in the water and filter through glass wool two or three times until crystal clear. Place in a dust-free oven at 40° C in a flat dish and let the medium evaporate to half its original volume. Cool, and keep in dropping bottle.

The chloralphenol is made from equal parts by weight of chloralhydrate and crystals of pure phenol or carbolic acid, heated over a water-bath for 5 to 10 minutes.

This technique works better for Mallophaga than for Anoplura whose tough hide sometimes prevents penetration of chemicals and clearing. It is a curious thing that some sucking lice will clear and make perfectly transparent mounts and others from the same batch become only semi-transparent: the same trouble occurs with the KOH-balsam method, and is not the fault of the Hille Ris Lambers technique.

Reference

D. Hille Ris Lambers. 1950. On mounting aphids and other soft-skinned insects. Entom. Berichten 13:55-58.

—*G. J. Spencer, University of British Columbia, Vancouver.*

THE CONOPIDAE (DIPTERA) OF BRITISH COLUMBIA

KENNETH G. V. SMITH
Hope Dept. of Entomology, University Museum, Oxford, England

Through the kindness of Dr. G. G. E. Scudder I have recently been able to study a collection of Conopidae, taken in British Columbia by Professor G. J. Spencer, of the University of British Columbia. Since the collection (104 specimens) was a comparatively large one for this rather rare family it seems worth while to review all the species hitherto recorded from British Columbia. The classification followed is that of Parsons (1948) with additional synonomy from various papers by Camras and others. Keys for the determination of North American Conopidae will be found in the references. A list is given of collectors names and initials.

CONOPINAE

Physoconops obscuripennis (Williston)

Conops obscuripennis Will., 1892, Trans. Conn. Acad. Arts & Sci. 4:328-9.

Conops brachyrhynchus Macquart of Williston and others in error.

Conops foxi Van Duzee, 1927, Proc. Calif. Acad. Sci. 16:574.

Camras (1955:181) includes British Columbia in the range of this species. Western specimens have the posterior margin of the wing hyaline which led Van Duzee (1927) to describe them as a distinct species, *foxi*. New data: Kamloops, 13.vi.1943, G.J.S.

Physocephala burgessi (Williston)

Conops burgessi Williston, 1882, Trans. Conn. Acad. Arts & Sci., 4:337.

Physocephala brevirostris Van Duzee, 1927, Proc. Calif. Acad. Sci., 16:579.

Camras (1957:213) includes B.C. in the range of this species, but gives no details. New data: Cobble Hill, 16.iv. 1912, Hooke Coll.; Goldstream 15.vii. 1923, K.F.A.; Newcastle Is., Nanaimo, 10.vi.1925, G.J.S.; Quesnel, 16.vii.1947, 20.vii.1947, 31.vii.1948, 14.vi.1949, G. J. S.; Salmon Arm, 20.vi.1929, H.B.L.; Salvus, 17.viii.1946, G.J.S.

Physocephala texana (Williston)

Conops texanus Williston, 1882, Trans. Conn. Acad. Arts & Sci., 4:338.

Conops affinis Williston, Trans. Conn. Acad. Arts & Sci., 4:339.

Conops ochreiceps Bigot, 1887, Ann. Soc. Ent. France, 7:39.

Physocephala humeralis Van Duzee, 1927, Proc. Calif. Acad. Sci., 16:580.

Physocephala humeralis simulans Van Duzee, 1927, Proc. Calif. Acad. Sci., 16:581.

Physocephala aurifacies Van Duzee, 1927, Proc. Calif. Acad. Sci., 16:581.

Physocephala buccalis Van Duzee, 1927, Proc. Calif. Acad. Sci., 16:582.

Physocephala rubida Van Duzee, 1934, Ann. Ent. Soc. Amer., 27:315.

Camras (1957:213) includes B.C. in the range of this species, but gives no details. The high variability of *P. texana* has resulted in a number of synonyms. The species has been bred from nests of the Bembicid wasps *Bembix comata* Parker and *B. occidentalis beutenmuelleri* Fox (*vide* Bohart and MacSwain, 1939, Bull, So. Calif. Acad. Sci., 38: 84 and 1940, Pan Pacific Ent., 16:16). New data: Kamloops, 16.vii.1934, 25.vii.1937, 13.vi. 1943, G.J.S.; Penticton, 16.viii.1920, W.D.; Quesnel, 13.vii.1948, G.J.S.; Summerland, 26.vii.1920 (no captor given); Walhachin, 1.vi.1917, E.R.B.

Physocephala marginata (Say)

Conops marginata Say, 1823, Jour. Acad. Nat. Sci. Philad., 3:82.

Physocephala dakotensis Van Duzee, 1934, Ann. Ent. Soc. Amer., 27:317.

Physocephala stylifer Van Duzee, 1934, Ann. Ent. Soc. Amer., 27:318.

Parsons (1948:232) records a specimen in the American Museum of Natural History from Nicola Valley, B.C.

DALMANNIINAE

Dalmannia picta Williston

Dalmannia picta Williston, 1883, Trans. Conn. Acad. Arts & Sci., 6:94.

This is the first member of this subfamily recorded from Canada. One male, Kamloops, 24.v.1935, G.J.S.

MYOPINAE

Myopa vesiculosa Say

Myopa vesiculosa Say, 1823, Journ. Acad. Nat. Sci., Philad., 3:80.

Myopa apicalis Walker, 1849, List of Dipt. Ins. in B.M., 3:679.

Myopa bistria Walker, 1849, *loc. cit.*: 679-80.

Myopa conjuncta Thomson, 1868, Eugenies Resa, Diptera: 515-6.

Glossigona maculifrons Bigot, 1887, Ann. Soc. Ent. France, 7:206-7.

Myopa utahensis Stains and Knowlton, 1940, Proc. Utah Acad. Sci. Arts Letters, 16:51.

Not previously recorded from B.C., but known from Quebec. New data: Chilcotin, 28.v.1929, G.J.S.; Salmon Arm, 4.v.1930, H.B.L.

Myopa longipilis Banks

Myopa longipilis Banks, 1916, Ann. Ent. Soc. Amer., 9:197.

Previously only known from California, Idaho, Oregon, Utah and Washington. New data: Cobble Hill, 15.iv.1912, Hooke Coll.

Myopa rubida (Bigot)

Glossigona rubida Bigot, 1887, Ann. Soc. Ent. France, 7:206.

Myopa tectura Adams, 1903, Kans. Univ. Sci., Bull., 2:35.

Myopa clausa var. *aperta* Roder, 1889, Wein. Ent. Zeit., 8:5.

Myopa seminuda Banks, 1916, Ann. Ent. Soc. Amer., 9:198.

Not previously recorded from Canada. Camras (1953:101) states that it is commonest in Washington, which adjoins B.C.; it appears to be fairly common in B.C. as the present collection contains nine specimens with data as follows: Salmon Arm, 3.v. 1920, 17.v.1932, 27.v.1932, H.B.L. (on shepherd's purse); Vancouver, 4.v. 1931, H.B.L.; Vernon, 1.v.1920, M.H.R.; Victoria, 28.vi.1919, 29.vi.1919, W.D.

Myopa clausa Loew

Myopa clausa Loew, 1866, Centuriae VII, no. 72:101.

Camras (1943:101-2) gives the range of this species as 'Southern Canada and United States (Maine to Georgia, West to Washington and California.)'. He does not specify a Canadian province, neither does Parsons (1948:238). New data: Chilcotin, 13. vi.1921, E.R.B.; Kamloops, 12.vi.1946, G.J.S.; Quesnel, 24.v.1949, 28.v.1949, 30.v.1949, H.R.M.; 26.vi.1949, G.J.S.; Yale (pair *in copula*), 24.v.1948, G. J. S.; Cariboo Distr., Sorenson Lake, 25. v.1959, G.G.E.S.

Myopa vicaria Walker

Myopa vicaria Walker, 1849, List of Dipt. Ins. in B.M., 3:679.

Myopa pilosa Williston, 1885, Trans. Conn. Acad. Arts & Sci., 6:383-4.

Not hitherto known from B.C., but recorded from Ontario and Quebec in Canada and the type in the British Museum is from Nova Scotia. I have also seen a specimen from Saskatoon, Sask., 23.iv.1943, P. Larkin. New data: Marpole, 1.iv.1950, coll. Farr. Peace River, 1949, D.G.H. Vancouver, 1.iv. 1949, G.B.R.; 1. iv.1950 (Univ. campus), H.J.; 2.iv.1950, coll. Richard. 20.iii.1950, E.F.; 9.iv.1950, H.A.M.; 4.iv. 1950, H.W.M.; 1.iv.1950, H.R.M.; 29. iii.?, M.O.

Zodion fulvifrons Say

Zodion fulvifrons Say, 1823, Journ. Acad. Nat. Sci. Philad., 3:83.

Zodion abdominalis Say, 1823, *loc. cit.* 3:84.

Myopa rubrifrons Desvoidy, 1830, Mem. Sav. etr. Acad. Sci. Paris, 2:247.

Zodion flavipenne Bigot, 1887, Ann. Soc. Ent. France, (6) 7:204.

Zodion lativentre Graenicher, 1910, Canad. Ent., 42:26.

flodion sayi Banks, 1916, Ann. Ent. Soc. Amer., 9:194.

Zodion obscurum Banks, 1916, Ann. Ent. Soc. Amer., 9:194.

? *Zodion bilineata* Van Duzee, 1927, Proc. Calif. Acad. Sci., 16:586.

Camras (1944:122) includes Southern Canada in the range of this species and Parsons (1948:240) mentions specimens seen from Nova Scotia and Ontario. Severin (1937, Ent. News, 48:243) has found this species as a parasite of worker honey bees in Dakota. New data: Chilcotin, 23.vi.1929, 20.vii.1930, G.J.S. Jesmond, 27.vi.1943, 20.vi.1943, G.J.S.

Zodion intermedium Banks

Zodion intermedium Banks, 1916, Ann. Ent. Soc. Amer. 9:193.

Zodion occidentale Banks, *loc. cit:* 194.

Zodion reclusum Banks, *loc. cit:* 194.

Zodion basalis Van Duzee, 1927, Proc. Calif. Acad. Sci., 16:586.

Previously known from Quebec and Ontario in Canada, and U.S.A. New data: Quesnel. 10.vi.1947, 19.vi.1949, G.J.S.; 10.v.1948, H.R.M.

Zodion ?perlongum Coquillet

Zodion perlongum Coquillet, 1902, Can. Ent., 34:199.

Males of this species are usually indistinguishable from *Z. fulvifrons*, but one male in the present collection

has a very rufous abdomen and as Camras remarks in his key (1944:120) 'Some of the larger and more rufous individuals are probably males of *perlongum*.' A definite record for Canada if not for B.C. is a female in the Hope Dept., Oxford, from Ottawa, Ontario, 21.vii.1897, Mary Holmes. The data on the B.C. male which I can only place doubtfully as *Z. perlongum* are Kamloops, 18-22.vi.1954, G.J.S.

Occemyia propinqua (Adams)

Oncomyia propinqua Adams, 1903, Kans. Univ. Sci. Bull., 2:32.
Oncomyia augusticornis Van Duzee, 1927, Proc. Calif. Acad. Sci., 16:595.
Oncomyia longipalpis Van Duzee, 1934, Ann. Ent. Soc. Amer., 27:321.

Camras (1945:218) gives Southern Canada and United States as the range of this species, but neither he nor Parsons (1948:244) give locality details. New data: Kamloops, 25.vii. 1937, 23.vii.1939, 22.vii.1945, 22.viii. 1958, G.J.S.; Quesnel, 19.vi. to 2.vii. 1949, G.J.S.; Royal Oak, 8.ix.1925, G. J. S.; Soda Creek, 27.vii.1949, G.J.S.

Occemyia nigripes Camras

Occemyia nigripes Camras, 1945, Ann. Ent. Soc. Amer., 38:218-9.

Described from Ontario with paratypes from Quebec, Ontario, Manitoba, all parts of the United States and Guatemala. New data: Australian, 15.viii.1948, G.J.S.

Occemyia loraria Loew

Oncomyia loraria Loew, 1866, Centuriae VII, No. 74. pp. 101-2.
Oncomyia baroni Williston, 1883, Trans. Conn. Acad. Arts & Sci., 6:97-8.
Oncomyia brevirostris Van Duzee, 1927, Proc. Calif. Acad. Sci., 16:593.
Oncompia aequalis Van Duzee, *loc. cit.*, 16:594.
Oncomyia terminalis Van Duzee, *loc. cit.*, 16:594.
Zodion bimaculata Curran, 1933, Amer. Mus. Novitates, 673:7.
Oncomyia frontalis Van Duzee, 1934, Ann. Ent. Soc. Amer., 27:322.

Previously recorded from Ontario and the range also includes the United States. New data: Quesnel, 31.vii. 1947, 10.vi.1948, 19 to 26.viii.1949, G. J. S.

Occemyia modesta Williston

Occemyia modesta Williston, 1883, Trans. Conn. Acad. Arts & Sci., 6:96.

Camras (1945:220) gives the range of this species as southwestern Canada and western United States, east to Saskatchewan, Colorado and New Mexico. New data: Agassiz, 11.ix.1925, G.J.S.; Chilcotin, 23.vi.1929, G.J.S.; Midday creek, 11.viii.1920, N.I.C.; Royal Oak, 8.ix.1925, G.J.S.; Victoria, 8.ix.1925, G.J.S.

Occemyia luteipes Camras

Occemyia luteipes Camras, 1945, Ann. Ent. Soc. Amer., 38:220-1.

Described from Washington with paratypes from California, Washington, Idaho, Utah and Colorado. New data: One female from Agassiz, 11.ix 1925, G.J.S.

There are four male Occemyia which I am unable to determine to species. Intermediates in size and coloration occur in the genus and without the females such examples are impossible to determine with certainty.

LIST OF COLLECTORS

E.F.—E. Fridell	H.J.—H. Johnson
E.R.B.—	H.R.M.—
E. R. Buckell	H. R. MacCarthy
G.B.R.—G. B. Rich	K.F.A.—K. F. Auden
G.G.E.S.—	M.H.R.—
G. G. E. Scudder	M. H. Ruhmann
G.J.S.—G. J. Spencer	M.O.—M. Oswell
H.A.M.—H. A. Magel	N.I.C.—N. I. Cutler
H.B.L.—H. B. Leech	W.D.—W. Downes

D.G.H.—not known

References

Bohart, G. E., 1938, Synopsis of the genus **Dalmannia** in North America (Diptera, Conopidae), Pan Pacific Ent., 14 (3): 132-136.

Camras, S., 1944, Notes on the North American species of the **Zodion fulvifrons** group (Diptera, Conopidae), Pan Pacific Ent., 20 (4): 121-128.

Camras, S., 1945, A study of the genus **Occemyia** in North America (Diptera, Conopidae), Ann. Ent. Soc. America, 38: 216-222.

Camras, S., 1953, A review of the genus **Myopa** in North America (Diptera, Conopidae), Wasm. Journ. Biol., 11: 97-114.

Camras, S., 1955, A review of the new world flies of the genus **Conops** and allies (Diptera, Conopidae), Proc. U.S. Nat. Mus., 105: 155-187.

Camras, S., 1957, A review of the new world **Physocephala** (Diptera, Conopidae), Ann. Ent. Soc. America, 50: 213-218.

PERSISTENCE OF SEVIN AND DIAZINON RESIDUES ON FRUITS[1]

K. WILLIAMS[2]

Since Section B 15.002 of the Regulations under the Food and Drugs Act established official Canadian tolerances for pesticide residues (Morrell, 1957), the determination of such residues on fruits has become more important than heretofore. Diazinon [*O,O*-diethyl *O*-(2-isopropyl-4-methyl-6 - pyrimidinyl) phosphorothiate; Geigy Agricultural Chemicals New York, N.Y.] and Sevin (1-naphthyl N-methylcarbamate; Union Carbide Chemicals Company, White Plains, New York) are recommended for the control of several tree fruit pests in the Okanagan Valley of British Columbia (Anon., 1959). It is generally acknowledged that the type of formulation, or the addition of surfacants may markedly affect both the initial deposit of pesticides, and the persistence of the residue (Gunther and Blinn, 1955). This paper deals with the residues found on apples and cherries that had been sprayed with commercial formulations of Diazinon or Sevin.

[1]Contribution No. 14 from the Regional Research Station, Canada Department of Agriculture, Summerland, British Columbia.

[2]Chemist.

Methods and Materials

Duplicate single tree plots of young cherry trees were sprayed with a 25 per cent wettable powder formulation, or with a 25 per cent emulsifiable concentrate formulation, of Diazinon. Spray - concentration was one - half pound of actual Diazinon per 100 gallons of water; 30 gallons of spray liquid were applied to each tree with a hand spray gun.

In another experiment Diazinon was applied to two large plots of mature apple trees, and Sevin to five large plots. A standard air-blast concentrate sprayer moving at one mile per hour and applying 50 gallons of liquid per acre at a pressure of 300 pounds per square inch was used in this work. Details regarding spray formulations and application dates for this experiment are given in Table 1.

For assay of Diazinon residues, 50 cherries and 50 leaves were picked at random immediately after treatment, and one, four, eight and 14 days later. The samples of unwashed whole fruit were processed with n-hexane. A disc, one centimetre radius, was cut from

TABLE 1—Residues (Means of Five Determinations) of Sevin and Diazinon on Fruit of Three Varieties of Apple Trees after Several Applications of a Concentrate Spray.

Spray Dates	Materials	Amount per Acre per Spray	Residues Days after Last Spray, p.p.m.* 0	7	14	Harvest**
Golden Delicious						
May 23, June 6, 18 August 3	Sevin 50% w.p.	6 lb.	6.1	4.2	2.7	1.4
Red Delicious						
May 24, June 6, 20 August 9	Sevin 50% w.p.	6 lb.	6.2	3.4	2.8	0.7
Northern Spy						
May 24, June 6, 17	Sevin 50% w.p.	6 lb.	4.8	2.9	2.6	—
July 17, August 7	Sevin 50% w.p.	3 lb.	2.3	1.5	0.8	—
	Sevin 50% w.p.	6 lb.				
	Triton B-1956***	1 pt.	4.2	3.2	2.0	—
	Diazinon 25% w.p.	8 lb.	2.6	—	0.3	—
	Diazinon 25% w.p.	8 lb.				
	Triton B-1956	1 pt.	2.8	—	0.4	—

* Official Canadian tolerance: Diazinon, 0.75 p.p.m.; Sevin, 10 p.p.m.
** Golden Delicious, 29 days; Red Delicious, 41 days.
*** Rohm and Haas Co., Philadelphia, Pennsylvania.

each leaf in the 50-leaf sample and the 50 discs were processed as a single unit with n-hexane.

Apple samples for assay of Sevin residues were collected from all plots immediately after the final spray and seven and 14 days later. At harvest samples were taken from two plots. For the determination of Diazinon residues fruits were sampled immediately after the final spray and 14 days later. Samples of ten apples were picked at random from each of five selected trees in each plot; these were processed with chloroform to remove Sevin residues, or with n-hexane to remove Diazinon residues.

Aliquots of the stripping solutions were analyzed for Diazinon by a colorimetric method based on the hydrolysis of Diazinon to inorganic phosphate (Geigy Agricultural Chemicals, 1956) and for Sevin by a colorimetric method based on hydrolysis of Sevin to 1-naphthol (Miskus, R., University of California, Berkeley, unpublished results).

Results and Discussion

Immediately after spraying with six pounds of 50 per cent wettable powder per acre the residues of Sevin on apples (Table 1) were well below the tolerance of 10 parts per million. The maximum dosage recommended in the British Columbia spray calendar is 12 pounds of Sevin, 50 per cent wettable powder per acre, and the data indicate that, at this dosage, the last spray can be applied up to one week before harvest without exceeding the residue tolerance.

At the eight pound per acre dosage of Diazinon, 25 per cent wettable powder, the residue on apples was well below the tolerance of 0.75 part per million 14 days after the final spray (Table 1). The recommended dosage is 12 pounds per acre, and the data indicate that, at this dosage, the last spray can be applied up to two weeks before harvest.

The addition of a spreader-sticker, Triton B-1956, apparently had no effect on the initial deposit nor on the persistence of Sevin and Diazinon residues on apples.

TABLE 2—Residues (Means of Two Replicates) of Two Formulations of Diazinon on Fruit of Cherry Trees after One Application of a Dilute Spray.

Material	Amount per 100 Gal.	Residues, Days after Spraying, p.p.m.* 0	1	4	8	14**
Diazinon, 25% emulsifiable concentrate	2 lb.	5.8	4.6	2.4	0.7	0.3
Diazinon, 25% wettable powder	2 lb.	8.6	4.7	2.1	0.6	0.2

* Official Canadian tolerance, 0.75 p.p.m.
** Harvest.

Sevin is more persistent on apples than Diazinon. About 50 per cent of the initial deposit of Sevin remained on the fruit two weeks after the final spray in comparison with only about 15 per cent of the Diazinon. Since there is about a 50 per cent loss of Sevin in two weeks, a fairly reliable estimate of the residue at harvest can be made from a residue analysis before harvest.

The data from Diazinon residues on cherries (Table 2) indicate that the persistence is similar for the wettable powder and emulsifiable concentrate formulations, and that the residue is below tolerance eight days after spraying.

The analytical results for Diazinon on cherry fruit and foliage, and on apple foliage, immediately after spraying (Table 3) indicate that the residues on cherry foliage were much lower than on cherry fruit, or on apple foliage, when the spray was applied by a high-volume hand gun. Evidently there was greater "run-off" of spray liquid from the cherry foliage. It may be that, in low-volume concentrate spraying where there is no run-off, the initial residues on cherry and apple foliage would be similar.

TABLE 3—Average Residues of Two Formulations of Diazinon on Fruit and Foliage of Cherry Trees and on Foliage of Apple Trees Immediately after One Application of a Dilute Spray.

Materials	Amount per 100 Gal.	Residues, mmg. per sq. cm. Cherry* Fruit	Cherry* Foliage	Apple** Foliage
Diazinon, 25% emulsifiable concentrate	2 lb.	2.0	0.4	—
Diazinon, 25% wettable powder	2 lb.	3.5	0.7	2.9

* Means of two replicates.
** Mean of eight replicates.

Summary

Data are given showing the amount of Diazinon residues on cherries and apples, and Sevin residues on apples. Results indicate that Diazinon residues on cherries were similar for a wettable powder formation and an emulsifiable concentrate formulation. The addition of a surfactant to Diazinon and Sevin sprays on apples did not affect the magnitude of the initial residues nor the persistence of the spray residues. Sevin residues on apples were more persistent than Diazinon residues.

The author is indebted to F. E. Brinton for assistance in sampling and chemical analyses.

References

Anonymous. 1959. Control of tree-fruit pests and diseases. British Columbia Dept. Agr. poster, p. 1.

Geigy Agricultural Chemicals. 1956. Methods of analysis for Diazinon. Bulletin, pp. 9-12. New York, N.Y.

Gunther, F. A., and R. C. Blinn. 1955. Analysis of insecticides and acaricides, Pp. 23-24. Interscience Publishers, Inc., New York.

Morrell, C. A. 1957. Trade information letter No. 157. Canada Dept. Natl. Health and Welfare. Mimeo., pp. 1-12.

RESISTANCE TO DDT IN THE CODLING MOTH IN BRITISH COLUMBIA[1]

J. MARSHALL[2]

In 1934 Hough (5) determined that there was considerable variation in the ability of larvae of the codling moth, *Carpocapsa pomonella* L., from Colorado and from Virginia, to penetrate deposits of lead arsenate, and of several other codling moth insecticides. He attributed the variation to difference in vigour. Whatever the reason, from that time until the beginning of the DDT era in orchard pest control in 1946, evidence mounted that lead arsenate was gradually losing its effectiveness in many areas where the insect was a serious pest.

Particularly in arid, or semi-arid, areas such as the Okanagan Valley of British Columbia, DDT was a spectacular success; even indifferent application of the new insecticide proved adequate (6). Orchardists brought to the brink of ruin by the codling moth became successful again, and serious loss of fruit from codling moth injury became a thing of the past. But five or six years later there were hints of trouble. Extra applications of DDT were becoming common although weather conditions were not very favourable for the development of the insect. Spraying technique, however, had radically changed between 1949 and 1952 (7).

[1]Contribution No. 5 from the Regional Research Station, Canada Department of Agriculture, Summerland, British Columbia.

[2]Entomologist.

Air-blast spraying had replaced hand-gun spraying, and some of the new machines were woefully inadequate. We hoped that the trouble lay in the spray equipment, or in its operation.

Then came a disturbing experience. While visiting the deciduous fruit districts of Australia in 1954 I was shown an orchard in the Paracombe district of South Australia that was very heavily infested by the codling moth, although it had received ten thorough applications of DDT. Satisfied that the insecticide was up to strength, the Chief Horticulturist for South Australia, Mr. A. G. Strickland, was of the opinion that the codling moth in that orchard had become resistant to DDT. His opinion was experimentally confirmed by Smith (8).

Shortly afterwards Cutright (2) showed that the codling moth had become resistant to DDT in an orchard in Ohio. A year later Glass and Fiori (3) demonstrated that the same thing had happened in an orchard in New York State; and the following year Hamilton (4) reported that DDT-resistant codling moth was present in two orchards in the State of Washington. The latest published evidence of what is evidently an accelerating tendency comes from California where Barnes (1) has demonstrated the existence of a strain of the codling moth that is about four times as hard to kill with DDT as a strain that had not previously been exposed to DDT (L. D. 50 four times as great).

In British Columbia we continued to hope that reports of increasing codling moth infestations could be ascribed to faulty spraying, as indeed most of them appeared to be. But in June 1958 came word of a situation in an orchard near Kelowna that was evidently in a different category. Despite the application of four first-brood sprays of 50 per cent DDT wettable powder at the recommended dosage of 12 pounds per acre, about half of the crop was infested by codling moth larvae of the first brood by mid-June. This, in fact, was a considerably heavier infestation than in the non-sprayed trees in the Entomology Laboratory orchard at the same date. Without delay we commenced a laboratory experiment to determine if, finally, we had to deal with DDT-resistance.

Moths were reared simultaneously from infested apples taken from the Kelowna orchard (designated as Glenmore stock), and from apples taken from either the Entomology Laboratory orchard, or from a relatively isolated abandoned orchard (designated as laboratory stock). The laboratory orchard, from which about 80 per cent of the laboratory stock was taken, had never been sprayed with DDT, nor any other chlorinated hydrocarbon. Although, to the best of our knowledge, the abandoned orchard had received no DDT, it is possible that, for several years after the introduction of DDT (in 1946), it had received DDT in limited amount.

Female moths from both stocks were allowed to lay eggs on waxed paper. Small pieces of paper bearing a total of 5 or 10 eggs, about to hatch, were pinned to non-sprayed apples and to apples that had been sprayed to the beginning of drip with a water-suspension of 50 per cent DDT wettable powder and then allowed to dry. Spraying was done with a small De Vilbiss atomizer under constant air pressure of 15 pounds per square inch. Before the apples were sprayed the calyx basins and the stem basins of the fruits were filled with melted paraffin wax to restrict entries to a uniformly-sprayed surface. The apples were suspended by threads from racks in the insectary (Fig 1), and examined for codling moth entries two weeks after the eggs had been pinned to them. In all, 3000 eggs were used in the experiment.

The apples, variety Spartan, were sprayed with three concentrations of 50 per cent DDT wettable powder (Fig. 2): 0.5 gram, 1.5 grams and 4.5 grams per liter — amounts roughly equivalent to 4 pounds, 12 pounds and 36 pounds per acre. Chemical analyses of the apples showed the following

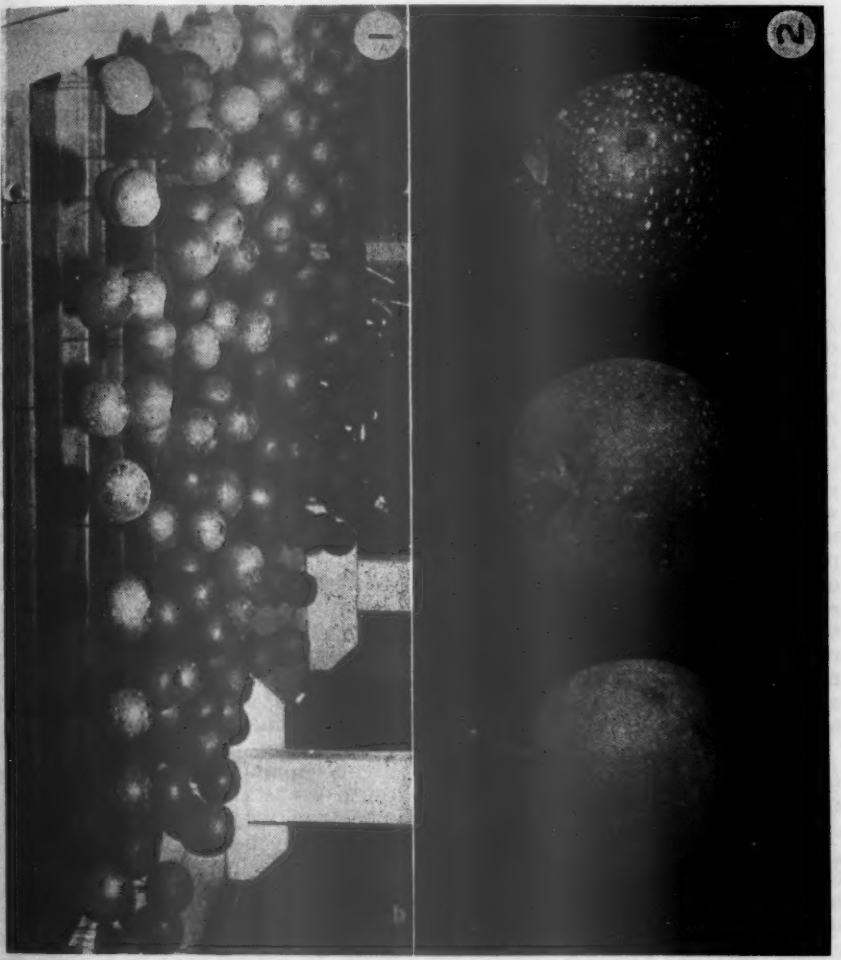

Fig. 1.—Apples suspended by threads in insectary for codling moth entry.

Fig. 2.—Apples sprayed with three concentrations of DDT showing deposits and codling moth entries.

average DDT deposits as parts per million: 1.07, 3.61, and 7.61 respectively. Analysis of the commercial 50 per cent DDT wettable powder that was used in the experiment showed it to be as guaranteed: Actual DDT 50 per cent, para para isomer content of the DDT 80 per cent.

The eggs of the two stocks of insects hatched in approximately the same numbers, 75.2 per cent to 98.7 per cent according to date of deposition. The larvae of the laboratory stock were just as capable of penetrating non-sprayed apples as those of the Glenmore stock (Table 1); presumably, therefore, they were just as vigorous. This is contrary to Hough's conclusions of twenty-five years ago with Colorado larvae resistant to a number of insecticides, and with non-resistant Virginia larvae; he found the non-

TABLE 1. Entries by resistant (Glenmore stock) and non-resistant (laboratory stock) codling moth larvae in non-sprayed and in DDT-sprayed apples.

DDT 50% w.p. gm./1.	Equivalent pounds per acre	DDT deposit p.p.m.	Stock	No. eggs	Entries % Non-sprayed apples	Entries % DDT-sprayed apples
0.5	4	1.07	Glenmore	300	91.4	89.6
			Laboratory	300	85.8	10.0
1.5	12	3.61	Glenmore	600	86.0	65.1
			Laboratory	600	86.1	4.4
4.5	36	7.61	Glenmore	600	90.4	49.4
			Laboratory	600	90.9	0.8

resistant larvae less vigorous. On the other hand, the laboratory stock larvae were far less capable of penetrating a DDT deposit than the Glenmore ones. The capacity of the Glenmore larvae to enter fruit sprayed with DDT at a dosage roughly equivalent to 36 pounds of 50 per cent wettable powder per acre was the more striking because the spray deposit was more uniform than in the orchard, and so, presumably more effective. Actually, at that dosage, three times as great as the official recommendation, over fifty times as many of the Glenmore larvae made successful entries as did the laboratory larvae.

Although the codling moth appears to be more difficult to control in the Glenmore orchard than in any other orchard in British Columbia, several growers in the Osoyoos, Oliver, and Keremeos areas have lately been having great trouble in keeping the insect at a low level, despite as many as six applications of DDT at recommended dosage. Hundreds of other growers are having to apply from one to three more codling moth sprays than they found necessary for some five years after DDT came into general use. In view of the clear experimental evidence of the development of resistance to DDT in the Glenmore orchard, and the strong circumstantial evidence of grower experience, it is evident that, to a varying degree, the effectiveness of DDT against the codling moth is declining.

We are concerned with both the genetical aspects of this problem and the role of the orchardist in it. Is the grower's role a passive one, or might his spraying affect the rate of development of resistance to insecticides? Will a low concentration of an insecticide select resistant strains of an insect more rapidly than a high concentration? Are trees, oversprayed on the bottoms and undersprayed on the tops, more likely to accelerate the selection of insecticide - resistant strains of insects than trees unformly covered with spray mixture? Is it desirable to use one insecticide for several years, then, before insecticide-resistance becomes evident, change to another for several years? Is a mixture of insecticides of significantly different chemical composition preferable to a single insecticide? Are highly toxic insecticides likely to select resistant strains of insects more rapidly than less potent ones? These have become significant questions for the fruit grower, and doubtless they will become even more so while chemical control remains our main line of defence against orchard pests. In an attempt to provide answers a new project is underway in which the Entomology Laboratories at Vineland Station, Ontario, and at Summerland, British Columbia, are collaborating.

Summary

1. The presence of a strain of the codling moth resistant to DDT has been experimentally demonstrated in British Columbia.
2. Over 50 times as many larvae from the resistant strain penetrated a heavy deposit of DDT as did larvae from a strain that had not been annually subjected to DDT sprays.

3. The fertility of the eggs of the two strains did not differ; nor did the capacity of the two stains of larvae to penetrate non-sprayed fruits.
4. DDT-resistance is evidently fairly widespread in the orchards of the South Okanagan area, but the degree of resistance is variable.

Acknowledgments

Much of the work in this experiment was done by these members of the staff of the Summerland Entomology Laboratory: Dr. M. D. Proverbs, Messrs. K. Williams, J. Newton and J. Ogilvie, and by Mrs. Bernice McDonald.

References

1. Barnes, M. M. 1958. A strain of codling moth in California resistant to DDT. J. Econ. Ent. 51: 693-694.
2. Cutright, C. R. 1954. A codling moth population resistant to DDT. J. Econ. Ent. 47: 189-190.
3. Glass, E. G., and B. Fiori. 1955. Codling moth resistance to DDT in New York. J. Econ. Ent. 48: 598-599.
4. Hamilton, D. W. 1956. Resistance of the codling moth to DDT sprays. J. Econ. Ent. 49: 866-867.
5. Hough, W. S. 1934. Colorado and Virginia strains of codling moth in relation to their ability to enter sprayed and unsprayed apples. J. Agr. Res. 48: 533-553.
6. Marshall, J. 1952. Applied entomology in the orchards of British Columbia. Proc. Ent. Soc. British Columbia (1951). 48: 25-31.
7. Marshall, J. 1958. Concentrate spraying in deciduous orchards. Canada Dept. Agr. Pub. 1020. pp. 1-47.
8. Smith, L. C. 1955. DDT-resistant codling moth. J. Dept. Agr. South Australia 59: 12-15.

OUTBREAKS OF GRANARY WEEVILS IN HOMES

G. J. SPENCER

University of British Columbia, Vancouver, B.C.

I have twice encountered two remarkable outbreaks of *Sitophilus granarius* Linn. the granary weevil, in homes in Vancouver; in both cases the telephoned reports were so alarming that I made special trips to investigate and in neither instance could I account for the situation.

In the first case, beetles had been issuing from under the quarter-round on the north and east sides of a first-floor back-bedroom for two days and were still streaming southwards and spilling over into the hall. Across the hall in the living room, beetles were slowly crawling around having apparently issued from under the quarter-round on the south side. Most remarkable of all, was a sheet of beetles some four feet across, in the grass of the lawn on the west side, between the houses. There was no indication where these lawn insects came from; they were slowly crawling around and around in a black carpet-like mass.

I enquired of the people if they had any shelled corn or grain stored in the basement or any forgotten sack of cereal of any kind; they had never had anything of the sort in the two years that they had lived there. I inspected the whole basement with greatest care and found no trace of any possible breeding material. I asked if they had ever kept chickens; they said they had not but the previous owners had kept poultry in the garage at the back of the lot, adjoining the lane, two years ago.

The only explanation I could give for this black horde of weevils was that the previous owners had kept sacks of corn or other grain in the basement as poultry feed, that rats or mice had stolen the feed and stored it somewhere in the walls, that the weevils had infested the feed until it was exhausted and were finally issuing from their breeding place in the huge populations which they had at-

tained in two years time.

In no way could I account for the black mass of weevils in the isolated mass on the lawn; they had not been seen travelling there—they just appeared there.

The second instance occurred in the home of an airman who had been in a rented house for about six months; a steady trickle of granary weevils was issuing from under the quarter-round in the hall upstairs and slowly crawling southwards down the hall; they had been emerging for two days before I inspected the house. Again I examined the basement with greatest care; there was no sign of grain anywhere and the floors and walls were sound and without cracks; moreover there was no place in the garden where anybody could have kept poultry. In this case, I could not even suggest the breeding place of the weevils and recommended the continuous use of the vacuum cleaner for their removal; there was no place to apply insecticides; the wall extended only to the floor below and not to the basement: there was no indication how any material for breeding could have been introduced into the wall from which the beetles were issuing.

A NOTE ON ENGINE VACUUM FOR ASPIRATING INSECTS[1]

W. H. A. WILDE[2]

Studies on vectors of stone fruit virus diseases often require test insects in large numbers. Usually these are Homoptera such as leafhoppers, psyllids, spittle bugs or aphids. Various methods have been devised (1) for aspirating large numbers of these. In my previous collecting with conventional mouth aspirators, minute particles of sand, plant and animal matter had appeared in the sputum, indicating that there was risk of permanent damage from irritation or myiasis (2). This note describes a well-proved method using part of the vacuum of 18 to 20 inches of mercury, available in most truck and car engines. The method differs in details from that of Moore (3) for collecting grasshoppers.

For vehicles with vacuum-operated windshield wipers, cut the wiper vacuum hose under the dashboard, insert a ⅜ in. brass T-shaped connection into the two cut ends, and attach an aspirator supply hose to the third outlet. The aspirator supply hose should be long enough to come through, or up to the level of, the dashboard to which it is attached for easy connection with the aspirator tubing.

For vehicles with electrically-operated wipers, bore a hole in the intake manifold below the carburetor for a source of vacuum. Thread the hole and insert a stop cock with a ⅜ in. hose connection for the vacuum line which is then taken through the fire wall to the interior of the vehicle and attached to the dashboard. This takes about 4 ft. of ⅜ in. windshield wiper hose. By inserting extra T-shaped connections more than one aspirator may be used from the vacuum line.

Window screens of 32/in. mesh should be used. The screens are not absolutely necessary, but the temperature on a hot, sunny day in a closed cab is often fatal to the insects and always uncomfortable for the operator. Connect a conventional straight aspirator (1) to the aspirator tubing. Start the motor and set it to run at medium idling speed. Attach the vacuum gauge to the nozzle of the aspirator and adjust for the required vacuum with a Hoffman clamp on the tubing close to the aspirator. For leafhoppers 2½ to 4 in. of vacuum is required, for spittle bugs 3 to 6 in.

Even where it is not possible to drive a vehicle close to the collecting site, time can still be saved by sweeping with 3 or 4 conventional nets, then returning to the vehicle to aspirate the catch. Release the catch inside

[1] Contribution No. 21, Regional Research Station, Department of Agriculture, Summerland, British Columbia.

[2] Entomologist.

the vehicle with the doors closed and aspirate the desired insects from the windshield, doors and screens. When 50 to 100 insects are in the aspirator, transfer them to a collecting jar. This avoids damage from swirling particles in the air stream or from the insects piling up. The transfer is easily made from a straight aspirator into a preserving jar, if the jar lid has a self-closing valve made from a piece of inner tube rubber. Shut off the vacuum by pinching the aspirator tubing, insert the nozzle of the aspirator in the jar and tap the aspirator gently to dislodge the insects. Shutting off the vacuum in this way does not interfere with the vacuum setting.

Leafhoppers collected with this method showed a better rate of survival in vector studies than those taken by conventional methods, probably because it was easy to select undamaged specimens.

References

1. Peterson, A. 1953. A manual of entomological techniques. 7th Ed. Pl. 68. Edwards Bros. Inc., Ann Arbor, Mich.
2. Hurd, P. D. 1954. "Myiasis" resulting from the use of the aspirator method in the collection of insects. Science 119:(3101):814.
3. Moore, H. W. 1943. A mechanical aspirator for sorting and counting insects in the field. Can. Ent. 75: 162.

A COLLECTION OF HYMENOPTERA FROM BRITISH COLUMBIA

By JOHN STAINER

This collection consists of species taken during the summer of 1939, at Okanagan Mission, with a few species collected at Vancouver Island points. I am indebted to Dr. R. Lambert, C. D. Miller, W. R. Mason, and G. S. Walley of the Division of Entomology, Ottawa, for their identifications; and to Prof. G. J. Spencer for his help with this paper. Most of the specimens are now in the National Collection at Ottawa, the remainder in my own collection in Parksville.

Of the 50 species listed 11 are not recorded from B.C. in the "Synoptic Cataloque of the Hymenoptera of America North of Mexico" (U.S. Dept. of Agriculture, April 1951). Some interesting points arise in geographical distribution. Of the Apoidea collected only 1 species has a continent-wide range; the ranges of 6 straddle the Rockies; and 23 are recorded West of the Rockies only. On the other hand of the other superfamilies 14 species have a continent-wide range, 3 more have ranges which straddle the Rockies; and only 3 are restricted to the West side of the Rockies. This follows a pattern evident in the Synoptic Catalogue, shown by these figures:

Per cent of American species with ranges which cross the Rockies

Genus *Andrena*	2.5
Genus *Dasymutilla*	11.2
Genus *Chrysis*	34.0

In the following list the specimens were taken at Okanagan Mission in 1939, unless otherwise indicated. Months of capture are given in Roman figures.

TENTHREDINOIDEA

Cimbicidae

Cimbex americana pacifica Cress. ♂ Parksville; 10. viii. 54.

Tenthredo varipictus Nort. ♀ Shawnigan Lake;—V. 54.

ICHNEUMONOIDEA

Ichneumonidae

Pimplinae

Xorides cincticornis Cress. Nanaimo;—viii. 52.

Ichneumoninae

Cratichneumon unifasciatorius Say. Parksville;—viii. 53. and 10. ix. 53.

CHRYSIDOIDEA

Chrysididae

Hedychridium fletcheri Bod. 24. v. Nearest previously recorded range: Alta., Ida., Ore.

Chrysis (Chrysura) pacifica Say. 5. v. and 22. v.

C. (C.) tota Aaron. 30. iv. Nearest previously recorded range: Ida., Colo.

C. (Chrysis) coerulans Fab. Nanaimo; 12. viii. 56. 23.v.

C. venusta Cress. 24. v. Previously recorded range throughout U.S.
C. (Pyria) fabricii Mocsary. 20. vi. Nearest previously recorded range: Calif., Ariz.

SCOLIOIDEA

Sphaeropthalminae

Dasymutilla nigripes Fab. (2) 27. iv. Not previously recorded west of Alta., Ariz.
D. vesta Cress. (2) 1.v. and 7.v. No previous record west of Rockies.

VESPOIDEA

Eumeninae

Ancistocerus antilope antilope Panz. Hornby Island;—viii.52.
A. catskill albophaleratus Sauss. (3) 22. v.
Symmorphus canadensis Sauss. 7. v.

Pompilinae

Anoplius insolens Banks. (7) 17. iv. to 26. vi.

SPHECOIDEA

Pemphredoninae

Passaloecus mandibularis Cress. Nanaimo; —. viii. 51.

Sphecinae

Podalonia communis Cress. (15) iv. to v. Ladysmith, V.I.; iv. to v. 39. Range Western U.S.; not recorded from B.C.
Sceliphron caementarium Drury. 8. v.

Nyssoninae

Bembix (Epibembix) comata Parker. (4) Cherry Point; 5.viii.42. Hornby Island; —.vii.52. Nanaimo;—.viii.52.

Philanthinae

Philanthus flavifrons Cress. (3) Nanaimo; 10.vi.51. French Creek, V.I.;—.vi.54.

APOIDEA

Andrenidae

Andrena candida Smith. ♂ ♀ 20.iv. Cherry Point; 4.v.42.
A. carliniformis Viereck and Cockerell. ♀ ♀ 8. and 14.v. Nearest previously recorded range: Calif., Utah, Wyo.
Andrena (?) *compactiscopa* Viereck 2 ♀ ♀ 14.v.
A. erecta Viereck. ♀ Cherry Point; 5.iv.42.
A. (?) *perarmata* Cockerell. ♂ 4 ♀ ♀ 1. to 16.iv.
A. prunorum kincaidii Cockerell 2 ♀ ♀ Kelowna; 10.v.39. Nanaimo;—.vii.52.
A. sladeni Viereck. 3 ♂ ♂ 5 ♀ ♀ 10. to 16.iv. to 24.v.
A. (?) striatifrons Cockerell. 2 ♀ ♀; 24.iv. to 24.v.

Halictidae

Halictus rubicundus Christ. 8 ♀ ♀ 15. to 16.iv. Cherry Point, 4.v.42.
H. virgatellus Cockerell ♀ 23.iv.

Megachilidae

Chelynia (Melanostelis) rubi Cockerell. ♀ 22.v. Nearest recorded range Alta., Wash., Calif., Colo.
Hoplitis (Monumetha) albifrons argentifrons Cress. ♀ 6.vi.
H. (Chlorosmia) fulgida fulgida Cress. ♀ 6.vi. Nearest recorded range Alaska, Yukon, Alta., Ore.
Osmia (Osmia) lignaria propinqua Cress. 13 ♂ ♂ 5 ♀ ♀ 4.iv. to 21.vi.
O. (Chalcosmia) coloradensis Cress. ♂ 8.v.
O. (C.) texana Cress. ♀ Nanaimo;—.vii.52.
O. (Cephalosmia) marginipennis Cockerell. ♂ ♀ 30.iv. and 16.vi.
O. (C.) montana Cress. ♂ ♀ 30.iv.
O. (C.) pascoensis Cockerell. ♀ 30.iv.
O. (Acanthosmoides) (?) *enixa* Sandhouse. ♀ 14.v.
O. (Nothosmia) densa densa Cress. ♂ 6.vi.
O. (N.) juxta subpurpurea Cockerell. ♂ 8.v.
Megachile (Delomegachile) melanophaea calogaster Cockerell. ♀ Parksville; 22. vi. 53.
M. (D.) melanophaea melanophaea Smith. ♀ Nanaimo; 1.viii.52.

Apidae

Anthophora bomboides standfordiana Cockerell. ♀ 21.vi.
A. pacifica pacifica Cress. ♂ 4.v.
Emphoropsis murihirta Cockerell. 8 ♂ ♂ 9 ♀ ♀ 2.iv. to 14.v. Nearest recorded range Calif.
Melecta pacifica Cress. 2 ♂ ♂ 16.iv.
Ceratina acantha submaritima Cockerell. ♀ 19.v.
Bombus mixtus Cress. ♀ Nanaimo, 5.viii.51.

A Note on the Oviposition of NYCTOBIA LIMITARIA Wlk.

On May 4, 1950, about 3:30 p.m., I noticed a female of the geometrid **Nyctobia limitaria** Wlk. flying in a leisurely way amongst the coniferous undergrowth bordering the creek at the Trinity Valley Forest Biology Field Station. I watched for about ten minutes before it flew down a steep bank and was lost; while under observation it settled about ten times on young Douglas fir, Engelmann spruce, and western red cedar. By following the moth I was able to pick out six eggs which it laid on the spruce and fir foliage. It showed no preference for either host, but was attracted to trees growing close to the water; twice it returned and laid a second egg on a tree of each species almost overhanging the creek. When ovipositing, the moth rested motionless, the wings half extended, on the upper side of a spray of foliage; the abdomen was curved downward and forward and the eggs were laid on the under side of the needles. On at least one occasion when the moth perched on a cedar its proboscis was extended and it appeared to be taking moisture from the surface of the foliage.

At the time these observations were made the sun was shining and the temperature at the nearby field station was about 58° F. In the vicinity of the creek the temperature was judged to be at least ten degrees colder and most of the understory was in shade.

—*J. Grant, Forest Biology Laboratory, Vernon, B.C.*

A PORTABLE TENT-CAGE FOR ENTOMOLOGICAL FIELD STUDIES[1]

L. H. McMULLEN AND M. D. ATKINS

Forest Biology Laboratory, Victoria, B.C.

The requirements for cages in entomological field work vary widely in accordance with the insect and host material under study. This paper describes the construction, advantages, and disadvantages of a lightweight, portable tent-cage developed during recent investigations of the Douglas-fir beetle, *Dendroctonus pseudotsugae* Hopk. It was designed to facilitate the study of the bark beetle and associated insects with known populations in logs under field conditions.

The tent cages shown in the accompanying illustrations are six feet long with sides and floor four feet wide, thus forming in cross section, an equilateral triangle with a height of approximately three and one half feet. The floor is of 10-ounce canvas with four corner loops of the same material and a plastic-screen drain to prevent the accumulation of water. The walls are of 22-mesh netting with ¼ inch rope running beneath cotton tape along the apex and extending as ties beyond each end. Nylon netting was found to be more durable than cotton mesh and has less tendency to stretch when damp. However, it deteriorates upon long exposure to sunlight, but this condition is seldom encountered in the shade of the forest.

A simple sleeve formed by three-foot extensions of the nylon mesh from the walls and floor, closed by gathering and tieing with cord proved satisfactory as a door (Fig. 1). This system worked better than a design in which flaps from the walls and floor were rolled on dowels to effect closure (Fig. 2). Further improvement might be made in the method of closing by employing inexpensive plastic zippers to fasten the free sides of a flap-type door.

The cages are set up by staking the tarpaulin floor with pegs through the loops to a level area of ground between two trees and fastening the ties, adding light rope if necessary, to the trees at or above breast height, depending on the distance between the trees. Two pieces of 2" x 4" lumber placed under the tarpaulin floor prevent the contents of the cage from pressing the canvas to the ground where it may rot. Short rollers about three inches in diameter help to ease the logs into the cages. The rollers, supported by the 2" x 4" wood beneath the floor, are then blocked in place with wooden wedges, holding the log off the floor and permitting complete air circulation around it.

These tent cages have one disadvantage when used in the Cariboo region of British Columbia. Rabbits and mice cause considerable damage to the material gathered together where the cages are closed. However, small tears can be repaired easily with patches of muslin applied on both sides of the netting with a rubber base cement between.

These cages have been used successfully for three years of Douglas-fir beetle brood and population studies. Although they could not be used during winter where snow may damage them, they have a number of advantages. Since they weigh only four pounds and can be folded tightly (12" x 14" x 3"), several can be carried by one man into areas inaccessible by road. The accessories, such as pegs, rollers and floor supports, can be made readily from material available in the forest. Two men can erect a cage in five minutes. A cage will accommodate a log five feet long and eighteen inches in diameter with sufficient room available for one to enter and examine the experimental material (Fig. 3). Manufactured cost per unit is about sixteen dollars on the West Coast.

[1] Contribution No. 568, Forest Biology Division, Research Branch, Department of Agriculture, Ottawa, Canada.

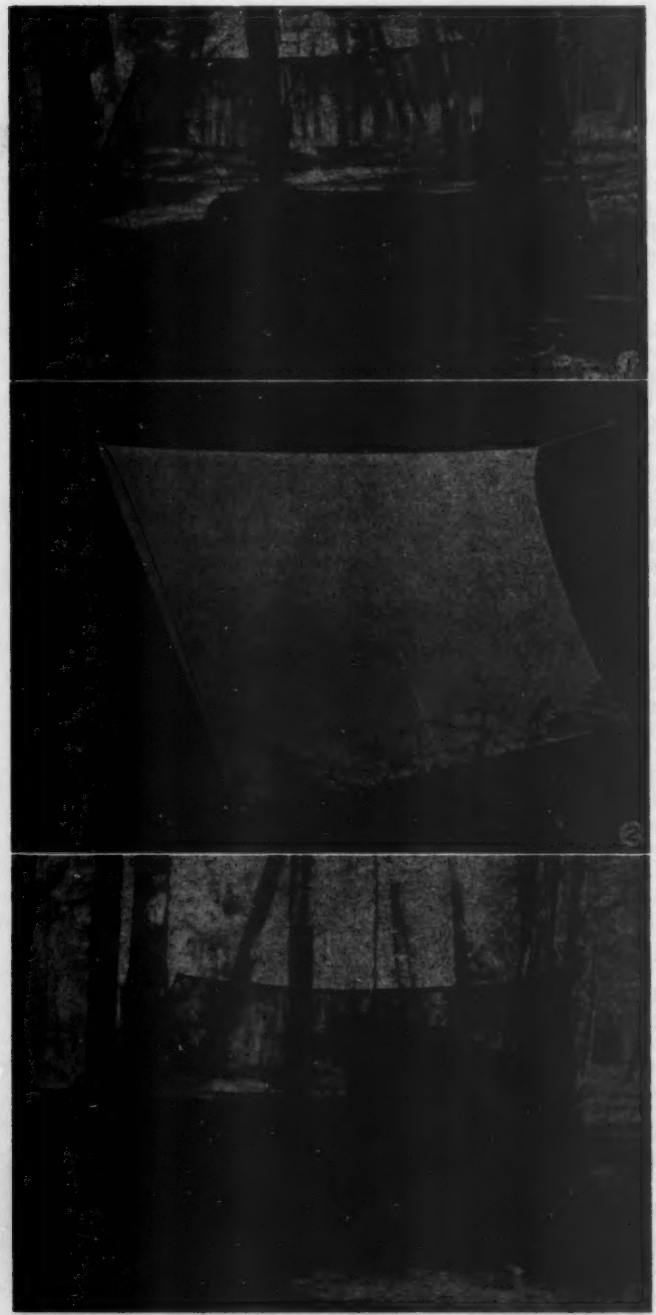

Fig. 1. Nylon-mesh tent-cage showing continuous apex ties and front opening closed by gathering of 3-foot sleeve tied with cord.

Fig. 2. Cotton-mesh tent-cage showing front opening closed by rolling flaps on dowels.

Fig. 3. Nylon-mesh tent-cage showing ease with which contents can be examined.

AN UNUSUAL MANIFESTATION IN THE NATURAL CONTROL OF THE PEAR PSYLLA, *Psylla pyricola* FOERST[1]

J. MARSHALL[2]

Although it appeared in British Columbia over sixteen years ago[3], the pear psylla, *Psylla pyricola* Foerst., was not, generally speaking, a very serious pest until 1958. Natural control has been, in the main, reasonably adequate. But since we have done no work on the biology of the insect in British Columbia, natural control, in all its forms, has been a matter for speculation. We had, however, formed an impression that the semi-arid Okanagan Valley is not as favourable for the development of the insect as, for example, more humid New York State where the pear psylla has long been a serious pest[4].

In the Okanagan Valley, and in the neighbouring Similkameen Valley, the summer of 1958, long, hot and dry, was in marked contrast with the mid-continent type of summer under which the pear psylla thrives. Just before the hot weather began we undertook an orchard experiment on the chemical control of the pear psylla in the Similkameen Valley and, incidental to the experiment, compiled infestation records on non-sprayed check trees before and after several days of hot weather. The records are given in Table 1. We repeated the experiment in a second pear orchard at Penticton in the South Okanagan and the corresponding records are given in Table 2.

TABLE 1—**Similkameen Orchard.** Number of pear psyllids, 20 leaves per tree, on check plot before and after hot weather (96° - 98°F.)

	May 15		May 26	
Tree	Living	Dead	Living	Dead
1	21	0	0	6
2	14	6	0	6
3	18	5	0	11
4	38	5	0	29
5	22	6	0	10
Total	113	22	0	62

Unseasonably hot weather occurred May 24 to May 27 when the maximum temperatures at the Entomology Laboratory were 87° to 88° F. Since the laboratory is situated on the shore of Okanagan Lake, which has a moderating effect on the temperature, the maxima in the Similkameen orchard are estimated to have been about 96° to 98° F. and, in the Penticton orchard, perhaps 92° to 94° F. Temperature maxima for the previous two weeks were 5 to 10 degrees lower. During the hot period the relative humidity was frequently below 30 per cent.

Both tables show that the pear psylla suffered heavy mortality between the time of the first and second observations, i.e., during the period of hot, dry weather. The only predator that appeared to be attacking the psyllids was the anthocorid bug, *Anthocoris antevolens* White; but it was so rare that it is doubtful if, in the course of a few days, it could have had much effect on the numbers of psyllids. In all likelihood, then, the chief lethal factor was the weather.

In the first to third instars the delicate pear psylla nymph excretes copiously a water - white, syrupy honey-dew beneath the protective covering of which it feeds. The more strongly sclerotized four and fifth

Fig. 3. Nylon-mesh tent-cage showing ease with which contents can be examined.

[1] Contribution No. 6 from the Regional Research Station, Canada Department of Agriculture, Summerland, British Columbia.

[2] Entomologist.

[3] Marshall, J., and H. F. Olds. The pear psylla in British Columbia. Proc. Ent. Soc. British Columbia 43:1-3. 1947.

[4] Slingerland, M. V. The pear tree psylla. Cornell Univ. Agr. Exp. Sta. Bull. 44:151-186. 1892.

TABLE 2—**Penticton Orchard.** Number of pear psyllids, 20 leaves per tree, on check plot before and after hot weather (92° - 84°F.)

	May 23		May 27	
Tree	Living	Dead	Living	Dead
1	39	9	8	32
2	36	6	18	96
3	29	9	15	49
4	20	4	19	13
Total	124	28	60	190

instar nymphs move about freely without such protection.

Following the hot weather we noticed that many of the dead, fourth and fifth instar nymphs appeared somewhat desiccated. Although the evidence was circumstantial, presumably they had been killed by excessive evaporation. Not so the fate of the first to third instar nymphs; the manner of their demise was as obvious as it was curious. Their protective gobbet of honey-dew had solidified to the consistency and appearance of pasteurized white honey, and immovable in their transformed excretion, they had become victims of their own metabolic processes. (See Figures 1 and 2.) Bonnemaison and Missonnier[3] working with the very closely related *Psylla pyri* in France report that hot, dry weather is particularly injurious to the early instars of that species but they do not mention crystallization of honey-dew as a contributory condition.

Despite the hot, dry weather in 1958, many growers were convinced that, as in several previous seasons, pear psylla infestation was serious enough to necessitate spraying once or oftener with an organic phosphate, i.e., malathion, Diazinon or parathion. So it is odd that, although there was apparently as heavy a winter carry-over of psyllids in the non-sprayed Entomology Laboratory orchard as in the commercial ones and even although temperatures in that orchard were somewhat lower than in many others, it suffered no psyllid damage. I suspect that commercial spray practice, particularly where it involves the application of organic phosphates, may in the long run encourage, rather than discourage, psyllid infestation. But if the natural control of the pear psylla in the Okanagan and Similkameen valleys is largely the outcome of unfavourable weather rather than of biological control, why should the application of any anti-psyllid chemical eventually favour the insect? It is unlikely that the question will be answered until the life-history and ecology of the pear psylla are studied under arid or semi-arid conditions.

[3] Bonnemaison, L., and J. Missonnier. Le psylle du poirier (psylla pyri L.) Morphologie et biologie. Methodes de lutte. Ann Epiphyties 2:263-331. 1956.

Summary

1. In the semi-arid Okanagan Valley the pear psylla has not, as a rule, been as serious a pest as in more humid pear-growing areas.

2. Hot, dry weather proved injurious to the pear psylla. The freely moving fourth the fifth instar nymphs presumably were killed by desiccation; the first, second and third instar nymphs were killed by the solidification of the gobbet of honey-dew within the protection of which they feed.

3. Biological control agencies apparently are not so important in suppressing the insect as the weather.

Acknowledgment

R. S. Downing and Kenneth Taylor assisted in taking records. The photographs are by S. R. Cannings.

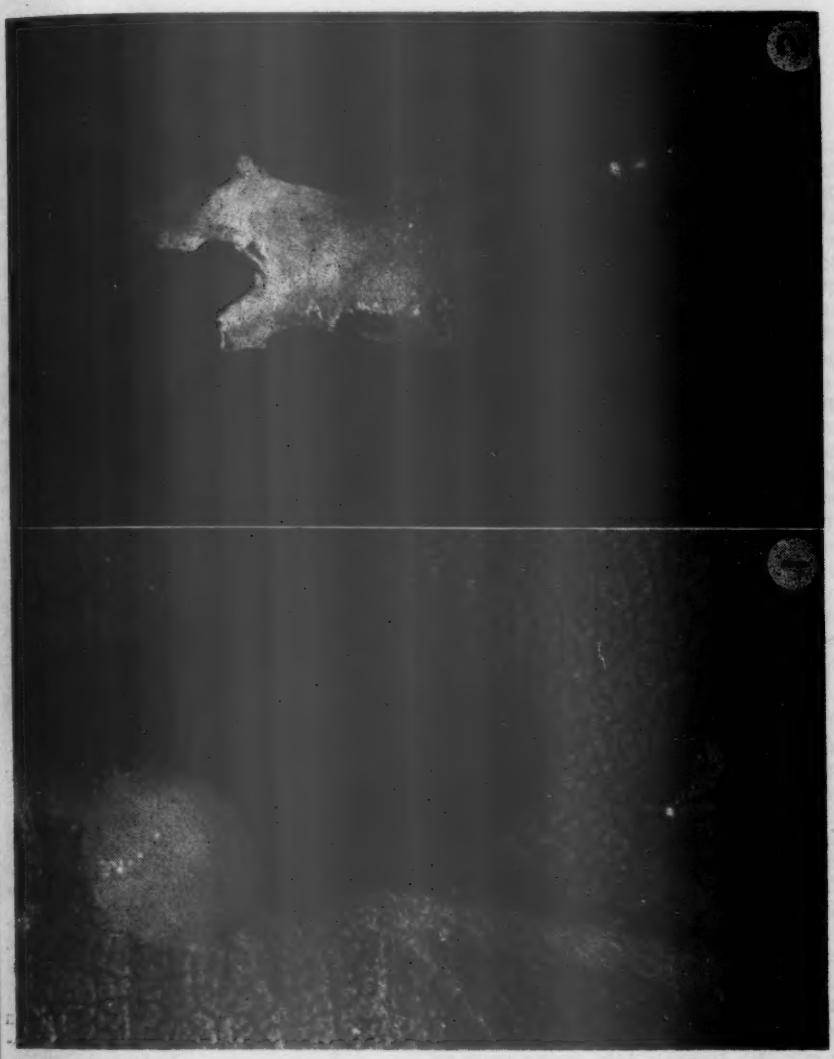

Fig. 1.—Solidified honey-dew (above) and live pear psylla nymph in liquid honey-dew (below).

Fig. 2.—Pear psyllids embalmed in their own crystallized honey-dew.

THREE INSECTS NEW TO VANCOUVER

G. J. SPENCER
University of British Columbia, Vancouver, B.C.

On July 10, 1958, Mrs. J. A. Shiers of 4816 Angus Drive, Vancouver, brought in several twigs and small branches of Copper beech on which all the leaves were heavily infested with blotch mines. The branches were caged and for the next two weeks produced tiny moths of the family Gracillariidae, genus *Lithocolletis*, but a far greater number of hymenopterous parasites of three species. The parasitism ran about 90 percent. Mrs. Shiers said that the beeches were 40 to 50 feet high and that a few mines had been noticed in the topmost leaves in 1957, but that in 1958 the whole appearance of the tree was spoiled; other trees in her neighborhood were not infested. This is the first time I have encountered this trouble and I can find no record of it on this continent or in England. The moths and their parasites have not been identified as yet.

The second unusual record came from a hardwood importing firm whose shipment of 1"x6" Tennessee cedar boards was producing hordes of beetles. These were half-inch long, longicorns of a beautiful bluish purple colour which Dr. Gorton Linsley identified as *Callidium schotti* Schaef. I am grateful to Mr. H. B. Leech of the California Academy of Sciences for getting these beetles identified for me. I kept them in a cage and for the next three weeks they rushed about furiously in jerks over the boards, spending much time mating. Eventually the females laid many eggs on the small portions of bark adhering to sides of the boards. When the eggs hatched the minute larvae moved into the bark and soon disappeared. However, none succeeded in becoming established, so it is unlikely that this insect will breed in our climate on local cedars. An entomologist from West Virginia told me that this beetle is specific to Tennessee or Eastern cedar.

The third record concerns a terrific infestation of Phylloxera in July and August 1958 on a four-foot English oak in my back yard, so extensive that every leaf was heavily infested. The insects caused pale blotches above where they were feeding so that the general effect was that of a fungous disease. The oak is six years old and has never shown this damage before. The Phylloxera cannot be keyed out amongst the 11 species that Duncan described from oaks in California so it may be either recently introduced into this Province or new to science.

The insect was in two forms, winged and wingless. The latter was shaped like a peg top, was larger in body than the winged ones and laid reddish brown oval eggs in semi- or in full circles. It rotated on its front legs, laying eggs like radii of a circle.

Its development is unknown, for the tree was so thoroughly sprayed three times that it is not likely that the Phylloxera survived.

Oaks less than 70 yards away on the boulevard had no similar infestation, so the origin of the insect is a mystery.

Reference

Duncan, Carl D. 1922. The North American species of Phylloxera infesting oak and chestnut. (Hemiptera, Phylloxeridae) Can. Ent. LIV. No. 12.

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